

**LPM Division 3, Geotechnical Engineering Office, CEDD**  
**Guidance Notes on Current Procedures on Supervision of Soil Nailing Works**

**1. DUTIES OF SITE SUPERVISORY STAFF**

**1.1 General**

- 1.1.1 Works Supervisors (WS) are responsible for the day-to-day supervision of works under the direction of Inspector of Works (AIOW/IOW/SIOW). In order to ensure the proper supervision of works, WS/AIOW/IOW/SIOW are required to get themselves familiar with the requirements of the Contract, in particular the specifications. They are required to supervise the construction, check the standard of works and adequacy of the safety measures implemented on Site by the Contractor, take samples of materials delivered to Site and escort the samples to the Employer's laboratories, carry out site measurements and keep relevant records.
- 1.1.2 The working procedures for WSs are given in the Project Administration Handbook, Chapters 7, 8 and 9 and CEDD Work Instruction GEO/LPM-OP-06/07-WI-01 : Site Staff Duties (In-house Administered Contracts).
- 1.1.3 All WSs should be aware that they have to carry out 100% supervision on all works to be covered up or hidden. **Insertion of steel bars and grouting of soil nails are classified as hidden work and are considered to be the most critical processes of soil nails construction. WSs are required to provide 100% supervision to these processes.**

**1.2 Duties of AIOW/IOW/SIOW**

- (i) To check that the Works are carried out according to specifications and drawings by identifying faulty materials, workmanship, etc;
- (ii) To check that the Contractor provides adequate safety and environmental precautionary measures during the course of the Works;
- (iii) To check that the Contractor follows the agreed works programme and method statements;
- (iv) To keep vigilance on any visual signs of distress on Site and in the surrounding and any apparent signs of abnormal ground conditions.
- (v) To report to professional staff on faulty workmanship, site problems, site safety, visual signs of distress, possible abnormal ground conditions, progress, quality of workmanship and adequacy of Contractor's resources for the Works;
- (vi) To provide on-the-job training to all his subordinates on the skills in carrying out supervision of various types of LPM works, site measurements, sampling and testing of materials for the Works;
- (vii) To monitor the works of all his subordinates;
- (viii) To ensure that site measurements, site diaries, record drawings, in-situ testing and other records are properly maintained and kept up-to-date;
- (ix) To ensure consistent supervision, site safety and measurement standard across sites under his supervision.
- (x) To prepare and submit monthly progress reports and any other returns as required by his superior;
- (xi) To check and verify bills submitted by the Contractor;
- (xii) To check that the Quality Procedures are followed by all subordinates;
- (xiii) To check the as-built drawings/records prepared by WS;

- (xiv) To recommend and check the overtime duties of all his subordinates; and
- (xv) To supervise the critical construction activities of reference nails for calibration purpose in TDR tests.

### **1.3 Duties of Works Supervisors**

- (i) To supervise contract works, check the standard of materials and workmanship against the Specifications and Drawings, carry out sampling of materials, supervise in-situ tests on Site, keep site records and undertake site measurements;
- (ii) To check that adequate safety and environmental precautions are provided by the Contractor for works to be carried out;
- (iii) To observe and record any obvious signs of distress on Site and in the surrounding;
- (iv) To observe and record any apparent abnormal ground conditions (e.g. presence of voids, obstructions, high water table) revealed during construction (e.g. during drilling and/or grouting);
- (v) To report to his superior on faulty workmanship and materials, site difficulties, visual signs of distress, possible adverse ground conditions, day to day progress of the Works and adequacy of site safety measures, etc;
- (vi) To check that the Contractor follows the agreed works programme;
- (vii) To check that the conditions of Excavation Permit, Environmental Permit or other permits are followed by the Contractor;
- (viii) To prepare as-built drawings/records within the time period set by the Engineer; and
- (ix) To perform other duties assigned by his superior.

## **2. SUPERVISION OF SOIL NAILING WORKS**

### **2.1 Administration works before nail construction**

#### **2.1.1 Method Statement and Materials for Soil Nails**

The Contractor is required to submit the following particulars of materials and method of construction of soil nails to the Engineer for approval:

- (i) method statement,
- (ii) details and samples of soil nail bars, nuts, washers, plates, connectors, centralizers, grout pipes, corrugated sheathing, conducting wire and packers for isolating the bond length,
- (iii) details of galvanizer to be employed for galvanizing the steel components,
- (iv) details of heat-shrinkable sleeve for protecting the connections between reinforcement bars,
- (v) details of corrosion protection to the threaded portion of the steel bar at soil nail head,
- (vi) details of permanent casing;
- (vii) details of working platform,
- (viii) details of dust and noise suppression measures,
- (ix) method of drilling and details of drilling equipment,
- (x) method of grouting and details of grouting equipment,
- (xi) method of measuring the volume of grout used for grouting of individual soil nails,

- (xii) method for sealing the mouth of the drillholes for maintaining the specified pressure head during grout setting,
- (xiii) details of equipment for testing soil nails, including test and calibration certificates, and
- (xiv) details of testing assembly including details of datum for deformation measurement and bearing pad.

2.1.2 The Engineer's Representative, with the assistance of AIOW/IOW/SIOW, shall comment and approve the proposal(s) prior to commencement of soil nailing work.

2.1.3 The AIOW/IOW/SIOW shall keep a set of approved samples of materials for reference by WSs when required. For Schedule of Rates Contract, the samples shall be kept in the Engineer's Principal Office at the Depot.

## **2.2 Materials delivered to Site**

2.2.1 Upon the delivery of any materials to Site, the WS shall verify the materials against the Engineer's approval. The Contractor is required to provide to the Engineer's site staff a copy of the invoice, delivery notes, stockist's/supplier's certificate, Manufacturer's mill certificate, heat no. for steel bars, galvanizer's certificate for hot-dip galvanizing for each lot of galvanized steel bars delivered to Site.

2.2.2 The Contractor is required to provide to the Engineer's site staff a copy of the invoices, delivery notes and galvanizer's certificate for hot-dip galvanizing of each lot of connectors, steel plates and nuts for soil nails delivered to Site.

2.2.3 The AIOW/IOW/SIOW shall arrange for taking samples of steel bars and connectors from each lot of steel bars and connectors delivered to Site for delivery to the Public Works Central laboratory (PWCL) for compliance testing. The required compliance tests are detailed in Section 4. The WS shall label the selected samples and escort their delivery to the designated point for collection of PWCL.

2.2.4 The WS shall check whether steel bars are adequately threaded and the threaded portions are treated with the method as approved by the Engineer.

2.2.5 The WS shall check whether steel bars delivered on Site are in acceptable conditions (e.g. free from rust, grease or oil stains and damage to galvanized coating) and properly stored.

2.2.6 All materials delivered to site should be stored in accordance with manufacturer's recommendations or the ER's direction.

2.2.7 Any materials for soil nails that do not comply with the specified requirements shall be removed off Site as soon as possible.

## **2.3 Scaffolding and working platforms**

2.3.1 Scaffolding and working platforms for constructing soil nails shall be constructed in accordance with the design of the Contractor as accepted by the Engineer. Scaffolding for supporting working platforms is required to be inspected by a competent person at regular intervals of not exceeding 14 days immediately preceding each use in accordance with the Construction Site (Safety) Regulations. If the Contract requires the working platform to be certified or inspected by an

independent checking engineer, the AIOW/IOW/SIOW shall cross check the necessary certificate or document.

- 2.3.2 The WS shall check the size and spacing of the members used, connection, anchorage and supporting details of the scaffolding and working platforms erected on Site against the Contractor's submitted drawings/sketches and their compliance with the relevant Safety Regulations. He shall also check whether the scaffolding and working platforms are inspected as required in Section 2.3.1 above.
- 2.3.3 The AIOW/IOW/SIOW shall cross-check the scaffolding and working platforms during his routine site inspection. He shall also assess the overall stability of the scaffolding and working platforms prior to their use.
- 2.3.4 During the soil nailing works, the WS/AIOW/IOW/SIOW shall check that the scaffolding and working platforms are not being overloaded by plant or materials.
- 2.3.5 The WS/AIOW/IOW/SIOW shall instruct the Contractor to rectify all unsafe situations posed by the scaffolding and working platforms and report to the ER immediately if the Contractor fails to rectify such unsafe situations promptly.

## **2.4 Setting out of Soil Nails**

- 2.4.1 The Contractor is required to set out the positions of soil nails, including soil nails for pull-out tests on the slope face. On completion of setting out, the AIOW/IOW/SIOW or the ER shall, where specified in the Contract, invite the Design Engineer to visit the Site and check the positions of the soil nails, including the positions of the pull-out tests. For soil nails obstructed by surface boulders, existing structures, channels, utilities and trees etc, the Design Engineer may direct the WS/AIOW/IOW/SIOW to shift their positions. The AIOW/IOW/SIOW shall record all such directions and/or amendments on site diary. The Design Engineer is required to confirm all such directions given on Site by written instruction to the ER.
- 2.4.2 Upon receiving the instructions from the Design Engineer, the ER shall arrange to issue the instructions to the Contractor. The WS shall mark the changes or attach a copy of the sketches, if available, to the Contract Drawings. The WS shall check whether the Works are constructed in accordance with the amended details as ordered in the ER's instructions and marked the constructed soil nails on the as-constructed drawings kept on site. The AIOW/IOW/SIOW shall carry out routine check for the same. If amended Drawings are issued, the old version of the Drawings shall be boldly marked "Superseded". The AIOW/IOW/SIOW shall ensure that the latest version of the Drawings is used on Site.

## **2.5 Drilling of Soil Nails**

- 2.5.1 The WS shall check that the total length of drill rods available at the drilling location is sufficient for the specified length of the soil nails.
- 2.5.2\* The WS shall check the diameter of drill bits prior to drilling and instruct the Contractor to remove all undersized drill bits off Site.
- 2.5.3 The WS shall remind the Contractor to check whether any utility services in the vicinity of the Site will be affected by the soil nailing works.

2.5.4\* The WS shall carry out random check on the orientation and inclination of the drilling rod during drilling and that appropriate dust and noise suppression measures are being implemented.

2.5.5 The WS shall record the soil nail numbers, drillhole diameter and inclination in Standard Site Form GEO/CA/12.

2.5.6 For soil nails pull-out tests, WS shall ensure that the Contractor takes record of drilling record on Standard Site Form GEO/CA/13-1 and submits the completed form to the ER.

## **2.6 Fabrication and insertion of Soil Nails**

### **2.6.1 Fabrication of soil nails**

- (i) The WS shall check the sturdiness, outer diameter and type of the centralisers are correct and suitable for the drillholes.
- (ii) The WS shall check whether the centralisers are securely fixed to the steel bars at correct spacing.
- (iii)\* The WS shall check whether the grout pipes are terminated at a point less than 150 mm from the lower end of the steel bar and are fixed onto the steel bar by non-corrodible ties at spacing of not more than 2 metres. Grout pipes with signs of damage or side cut holes made at more than 150 mm from the lower end of the pipes shall be replaced.
- (iv)\* If conducting wire is specified, the WS shall check that the wires are free from defects with ends properly insulated, attached to the steel bar along the notch of each centralizer and are firmly fixed onto the steel bar.

### **2.6.2 Other checks prior to bar installation**

- (i) Prior to bar installation, the Contractor is required to give advance notice of the operation to the Engineer's site staff by submitting an Inspection Request Form. The Form shall be faxed to STO(G)/LPM31 for information for possible audit inspection.
- (ii)\* The WS shall check the no. and type of steel bars and connectors on Site and check whether the results of the compliance tests on the steel bars and connectors are OK.
- (iii) The WS shall check whether there is any damage to the galvanized surface of the steel bars. Steel bars with damaged galvanized surfaces shall not be used unless the damaged surfaces have been made good to the satisfaction of the Engineer.
- (iv)\* The WS shall measure the length of the steel bars. If the steel bars of the soil nails are made up of short lengths, the total length of each set of steel bars shall be measured against the specified length of the soil nails. All measurements made shall be recorded for reference and reporting.
- (v)\* The WS shall check whether adequate no. of connectors are available. Each length of the steel bars should be properly screwed onto the connector and tightened by means of a suitable sized wrench prior to insertion into the drillholes.
- (vi)\* For soil nails subject to pull-out tests, the WS shall check the following:
  - (a) the length to be grouted is isolated by means of an approved packer securely fixed to the steel bar.

- (b) the return pipe is securely fixed to the steel bar and terminated at the correct position.
- (c) the free length of the steel bars are properly wrapped or capped.
- (vii) The WS shall witness that the Contractor cleans up all the drillholes immediately prior to bar insertion (*cleaning is normally done by flushing out the loose materials inside the drillholes using a hose coupled with compressed air inserted to the bottom of the holes*).
- (viii) The WS shall spot check the depth of the drillholes prior to bar insertion. The length of drillholes shall be at least 50mm longer than the specified length of the soil nails to achieve 50mm cover to the steel bars at the bottom end.
- (ix) The WS shall record all abnormal observations on the Inspection Form and return the Form to the Contractor for follow up action and inform the AIOW/IOW/SIOW immediately. The WS may require the Contractor to re-submit an Inspection Request Form for re-inspection when all the abnormal observations have been rectified.

### 2.6.3 During bar insertion

- (i)\* The WS shall carry out 100% supervision during the whole process of bar insertion. He shall ensure that the length and type of steel bar inserted into each of the drillholes are correct.
- (ii)\* During bar insertion, the WS shall check that the connectors are properly tightened by means of a suitable sized wrench and that no jacking or hammering of the steel bars is undertaken by the workers. If an obstruction is encountered, the WS shall instruct the Contractor to withdraw the steel bar and the drillhole shall be cleaned before re-insertion.
- (iii)\* If heat-shrinkable sleeve is specified in the Contract, the WS shall check that the sleeves are installed in accordance with the Manufacturer's recommendation, type and method as approved by the Engineer. The finished surface of the sleeves shall be smooth and free from trapped air pockets, flaws, holes, cracks, burn marks and other defects. Before insertion, sufficient time must be allowed for the sleeves to cool down.
- (iv) The WS shall check that the top levels of the steel bars are correctly positioned to match with the intended level of the soil nail head.

## 2.7 Grouting of Soil Nails

### 2.7.1 Grouting plant and trials for cement grout

- (i) The WS shall check whether the cement grout mixing and pumping machines are the approved types.
- (ii) Prior to carrying out any grouting works on Site, the Contractor shall carry out trials on Site on cement grout including bleeding tests, flow cone tests and grout cubes for compressive strength tests for determination of the suitability of the proposed materials, mix proportion and grouting plant. For any change in materials, mix proportion or grouting plant, the Contractor is required to carry out further trials on Site.
- (iii)\* The WS shall supervise the site trials, witness the tests and escort the delivery of the grout cubes to the PWCL.
- (iv) The WS shall witness the calibration for grout volume measurement, if necessary.

## 2.7.2 Grouting of Soil Nails

- (i)\* The WS shall ensure that grouting of soil nails shall be carried out on the same day as bar insertion. Soil nail bars which have been left overnight without grouting shall be withdrawn from the drillhole and the drillhole shall be checked for cleanliness before re-insertion. The WS shall inform the AIOW/ IOW/SIOW or the ER if there are steel bars left inside drillholes overnight without grouting.
- (ii) Prior to carrying out any grouting operation on any day, the WS shall witness the bleeding test and flow cone test carried out by the Contractor on the cement grout.
- (iii) During grouting, the WS shall check that cement grout is injected into the drillholes through the grout pipes with grout return from the drillhole. Grouting shall continue until the spillage of grout at the mouth of grout pressure maintaining PVC pipe becomes good cement grout quality. The WS shall check that the grout pressure maintaining PVC pipe is securely installed at the mouth of drillhole. Drillholes with grout settlement shall be refilled immediately in accordance with the G.S. If grouting pressure is specified, the WS shall ensure that appropriate pressure is applied during the grouting operation.
- (iv) If excessive grout loss occurs in any drillhole, the WS shall report to the AIOW/IOW/SIOW or the ER as soon as possible and record in the site diary.
- (v) The WS shall carry out random checks on the batching and mixing of cement grout. He shall carry out random checks on the quality of the cement grout by means of bleeding tests and flow cone tests as appropriate. He shall also carry out random checks on the Contractor's records and measurement of grout volume.
- (vi) The WS shall record the quantity of cement used for each grouting operation by counting the number of bags of cement used in the operation.
- (vii) The WS shall supervise the making of grout cubes on randomly selected batches of cement grout for compressive strength tests.
- (viii) The WS shall record the in-situ tests carried out on cement grout on Standard Site Form GEO/CA/27 and the test cubes made for compressive strength tests on Standard Site Form GEO/CA/16.

## 2.8 Pull-out Tests for Soil Nails

- 2.8.1 The WS shall check the validity of the calibration certificates for the testing equipment.
- 2.8.2 The AIOW/IOW/SIOW shall obtain the test results from PWCL and check that the cement grout has reached a cube strength of at least 21 MPa.
- 2.8.3 The WS shall check that the equipment for pull-out tests is properly set up. During pull-out tests, the WS shall check that nobody is standing in front of the jack for safety reasons.
- 2.8.4\* The WS shall carry out 100% supervision of all pull-out tests. He shall record all the test data during the tests and ensure that the Contractor keeps an accurate record. The Contractor is required to submit pull-out test records on Standard Site Forms GEO/CA/13-1, GEO/CA/13-2 and GEO/CA/13-3 to the Engineer within 3 days of completion of the tests.

## **2.9 TDR Tests for Soil Nails**

- 2.9.1 If TDR tests are to be carried out, WS/AIOW/IOW/SIOW shall coordinate with the testing laboratory for the tests.
- 2.9.2 The AIOW/IOW/SIOW shall select the calibration nails and determine the division of the sample lots for TDR testing.
- 2.9.3 The WS/AIOW/IOW/SIOW shall provide the as-built lengths of all test nails to the testing laboratory after completion of the TDR tests and update the test results into the summary of test records.

## **2.10 Construction of Soil Nail Heads**

- 2.10.1\* The WS shall check the excavations for soil nail heads against the dimensions shown on the Drawings.
- 2.10.2\* The WS shall check that the reinforcement bars for soil nail heads are of the specified type and size, that the cover to the reinforcement is correct and that the dimensions of the formwork for soil nail heads are correct. If requirements of prefabrication yard are specified in the Contract, the WS/AIOW/IOW/SIOW shall ensure the rebar products are either supplied from the approved prefabrication yard or purchased rebars by the Contractor for on-site cutting and bending.
- 2.10.3\* The WS shall check that the bearing plates are securely locked in position by the nuts and that the size of the hole in the bearing plates is correct (i.e. not more than 2 mm clearance between the edge of the hole and the steel bars). If sprayed concrete is used for casting the soil nail heads, the steel plate shall be fixed after the first layer of the sprayed concrete which should be finished at least 25 mm above the bottom of the steel plate is applied. The steel plate shall then be hammered into position and the nut tightened prior to applying the second layer.
- 2.10.4\* The WS shall check that the correct grade of concrete is used and that the concrete is properly laid, compacted and cured.
- 2.10.5\* It is a good practice to uncover a number of soil nail heads from the batch cast on any one day at any site for examination of the quality of soil nail heads. The uncovering may be carried out either before applying the second stage sprayed concrete or after hardening of the concrete soil nail heads. The WS/AIOW/IOW/SIOW shall select a maximum of three soil nail heads to be uncovered for examination in accordance with the contractual requirement and/or the ER's instruction. The WS/AIOW/IOW/SIOW shall check whether any voids exist underneath the steel plates. If voids or other defects are found, he shall take record photographs, record in the site diary and report to the ER as soon as possible, and the whole batch of soil nail heads cast on the same day at that site shall be deemed to be defective. The contractor shall propose and take remedial action to the satisfaction of the Engineer.
- 2.10.6 The WS shall record the details of ready mixed concrete, slump tests and concrete cubes in Standard Site Form GEO/CA/17. The WS shall label the test cubes, complete the "Compression Test of Concrete Cubes Test Request (Form No. C Eng D (GEO) 2309)" and the Concrete Test Cube Register (Standard Site Form GEO/CA/16) and escort the delivery of the test cubes to the PWCL for testing.



## **2.11 Responsibility of the AIOW/IOW/SIOW**

The AIOW/IOW/SIOW is responsible for supervising construction of calibration nails for TDR tests as stated in Section 1.2 (xv), for overseeing the duties of the WS as stated in Sections 2.2 to 2.10 above and for carrying out random checks on the Works during his routine site inspections. He shall report to the ER on:

- (i) progress of the Works;
- (ii) faulty materials and workmanship;
- (iii) problems encountered on Site;
- (iv) visual signs of distress;
- (v) possible abnormal grout conditions;
- (vi) adequacy of resources for the Works;
- (vii) site safety and environmental standards;
- (viii) particular incidents that happened on Site.

## **3. RECORD OF INSPECTION/SUPERVISION**

- 3.1 The WS shall record all site activities, the approximate amount of work done, weather conditions, labour and plant force on Site, materials delivered to Site, visitors to Site and particular incidents that happened on Site in the Site Diary. He shall sign the site diary on a daily basis. The AIOW/IOW/SIOW and the Contractor's Site Agent are required to check and sign each sheet of the Site Diaries within 7 days. The ER is required to check and sign the Site Diaries at weekly intervals.
- 3.2 The WS shall keep records of his inspection/supervision on Standard Site Forms as listed in Section 6. He shall verify the soil nail records submitted by the Contractor and sign against the relevant items of records.
- 3.3 On completion of the relevant part of the Works, the WS shall update the as-constructed details onto the As-constructed Drawings. Upon the completion of the Works, the AIOW/IOW/SIOW shall check whether all the changes have been incorporated by the WS onto the As-constructed Drawings before passing the Drawings to the ER.

## **4. COMPLIANCE TESTING FOR SOIL NAILS**

### **4.1 Steel bars**

- (i) Tensile strength (CS2)
- (ii) Bend test and rebend test (CS2)
- (iii) Unit mass test (CS2)
- (iv) Galvanized coating thickness (BS EN ISO 1461:1999 as specified)
- (v) Nuts (BS 4190:2001 as specified)

### **4.2 Connectors**

- (i) Tensile test (GS, Section 15)
- (ii) Permanent elongation test (GS, Section 15)
- (iii) Galvanizing coating thickness (BS EN ISO 1461:1999 as specified)

### **4.3 Cement Grout**

- (i) Flow Cone test (ASTM C939 version as specified)
- (ii) Bleeding test (ASTM C940-98a version as specified)
- (iii) Compressive strength test (CS1)

## **5 SPECIFICATION FOR SOIL NAILING WORKS**

The specification for soil nailing works is specified in GS (2006 Edition) Section 7, Parts 3 and 4.

## **6. LIST OF SITE FORMS FOR SOIL NAILING WORKS**

- (i) Soil Nail Record - GEO/CA/12 (*see Appendix B*)
- (ii) Soil Nail Pull-Out Test Record - GEO/CA/13 (*this record is to be prepared by the Contractor*) (*see Appendix C*).
- (iii) Concrete Test Cube Register – GEO/CA/16 (*see Appendix D*).
- (iv) Ready Mixed Concrete Delivery & Slump Test Record - GEO/CA17 (*see Appendix E*).
- (v) Cement Grout Testing Record - GEO/CA/27 (*see Appendix F*).