WORK INSTRUCTIONS FOR ENGINEERS

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CHECKLIST FOR SUPERVISION OF SOIL NAILING WORKS

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No.	CHECKLIST ITEMS	ACKNOWLEDGED BY CONTRACTOR	CHECKED BY ENGINEER	
1.0	**EARTHWORKS FOR SOIL NAILED SLOPE (4V:1H)**	**SIGNATURE**	**YES**	**NO**
1.1	The construction sequences (stages of construction) shall be referred to the construction drawing.			
1.2	The soil excavation (4V:1H) shall not exceed **2m** height per stage before soil nails, horizontal drains and shotcrete surface are completed.			
1.3	The length of the excavation shall not exceed the contractor's **daily production rate** for soil nails, horizontal drains and shotcrete. Eg. If contractor could install soil nails and shotcrete for slope excavation of 10m length in a day, the length of excavation shall not exceed 10m.			
1.4	The next stage of excavation (after Item 1.2) shall proceed only after the soil nails, horizontal drains and shotcrete surface are completed.			
1.5	The 4V:1H slope surface shall be sprayed with 25mm thick shotcrete immediately after excavation. No portion of the slope should be left exposed at 4V:1H gradient for more than **three (3) hours**.			
1.5	Temporary slope protection using canvas shall be carried out to prevent slope erosion when directed by the Engineer.			
1.6	**Non-Compliance Record (NCR)** will be issued to contractor who refuses to comply to any of the construction sequence and conditions as highlighted in this checklist. The contractor shall then carry out the rectification works at his own cost and time to the specification requirements. No work shall be certified if the related NCR is not resolved.			
1.7	REMARKS:			
2.0	**MATERIAL**	**SIGNATURE**	**YES**	**NO**
2.1	Soil Nails • Only nails longer than 12m in length can be spliced using mechanical splicer approved by Engineer. • Corrosion Protection: • All steel bars, steel plates, washers and hexagon nuts shall be galvanised to the specified thickness. • A **magnetic gauge** shall be available at site when requested by Engineer to check the thickness of galvanise coat. • If threading of soil nail is not galvanised, the **threading** shall be **temporarily protected with plastic sheath or anti corrosion paint** to avoid corrosion. • **2 layers** of **zinc coater** (Nitoprime Zincrich or equivalent as approved) shall be applied to exposed threading or any part of the steel element where slight scratch of galvanise coat is found.			

	• Centraliser/Spacer: • Centraliser shall be of minimum diameter 12mm smaller than the nominal diameter of drilled hole. • Plastic centraliser shall be solid and not of collapsible type under the self weight of the nail. • If lantern type plastic centraliser is used, the contractor shall install the centraliser properly so that the **centraliser will not collapse under the weight of steel bar**. • The spacing of centralizers shall be maximum **4m c/c**.			
	Steel Welded Wire Fabric (BRC Mesh) • Lapping of mesh shall be **at least 400mm or two mesh grid** standard in both directions which ever is larger. • Tie wires shall be bent flat in the plane of the mesh and not forming large knot. • Spacer for cover. • Provide sufficient spacer (eg: at least 1m interval) and ensure the spacer is solid.			
2.3	Horizontal Drain • Provide as required and shown on drawings (slotted or perforated PVC pipe) with end cap. • Provide swellable waterstop (e.g. Fosroc's SW15@20 or equivalent as approved) at maximum intervals (e.g. 3m c/c spacing) as shown in the drawings. • Wrap around the PVC pipe with geotextile. • Wrap around of geotextile with steel wire at waterstop area shall be as shown in drawings.			
2.4	Grout for Nails • To achieve non-shrink grout effect, additives shall be added (e.g. Intraplast-Z, Sika, Cebex 100 or equivalent as approved). • Record name and percentage of the additives that have been used as follows: > _____ (name) > _____ (percentage by weight) • Have the additives been approved by the Engineer? > Yes / No • Have the details for batching and mixing proportion of grout material at field/site submitted and reviewed by the Engineer? • > Yes / No • At least 3 cube tests to be carried out and properly cured after every batching of grout to be tested at 7 days, 14 days and 28 days.			
2.5	Permanent Structural Shotcrete Facing • Have the details for batching and mixing proportion of shotcrete at field/site submitted and reviewed by the Engineer? • > Yes / No • Minimum cement content : 350kg/m^3 • Water cement ratio: 0.35 – 0.50 • **Mixing by hand** is **prohibited**.			

2.6	REMARKS:			
3.0	**NAIL INSTALLATION**	**SIGNATURE**	**YES**	**NO**
3.1	General procedures: • Ensure that **all** the following **materials/equipments** are **ready** before starting the drilling works for soil nail: • Sufficient diesel for drilling works. • Drill bit (min. **ϕ110mm**) in good condition for soil. • Hammer (min. **ϕ110mm**) in good condition for rock. • Sufficient cement for grouting. • Grout pipe is available. • Pump for grouting. • Additive for non-shrink grout. • Weighing machine or marked container to weigh additive. • Grout mixing portable water is available. • Centralisers/spacers. • 3 cubes for cube tests of grout. • **Measure** the diameter of drill bit and hammer as compared to the required diameter of soil nail as specified in the drawings. Any anomalies shall be reported immediately to the Engineer. > _____mm (diameter of drill bit for soil) > _____mm (diameter of hammer for rock) > _____mm (required soil nail diameter) • **Measure** the actual diameter of hole being formed. > _____mm • Mark clearly and accurately the point of the soil nail location. The drilled hole shall be located within 150mm of the designated location shown on drawing. • **All soil nails shall be grouted in the drilled hole at the same day when drilling is carried out**. Drilled holes that have been left for more than 6 hours shall be rejected. It is therefore advisable to **carry out grouting twice a day** for a working team, once in afternoon and once in evening once. • Ensure that the **length of drilled hole** (with 150mm extra drilling hole beyond the soil nail length) is sufficient. • At the point entry, the nail and horizontal drain inclination angle shall be within ± 3 degrees of the inclination as shown in the construction drawing. • Spacers shall be provided at maximum **4m** intervals for the whole length of nail with the last centraliser located at 300mm from the end of nail. • Record the depth and locations where the seepage of groundwater was observed (if any). • Inject grout from the lowest point of the drill hole. Remark: Grout pipe must be installed till the end of the soil nail and tremie bottom up or else the particular soil nail shall be rejected.			

	• Grout pipe shall only be removed from the hole after allowing grout to **overspill** from the hole **for at least 30 seconds** and **free from drilling effluent, soft mud, excessive sand content, watery/diluted cement grout**. • Grouting equipment shall have capability of continuous mixing and producing homogeneous grout which is free of lumps.			
3.2	REMARKS:			
4.0	**SHOTCRETING**	**SIGNATURE**	**YES**	**NO**
4.1	General procedures: • Slope surface shall be cleaned with high compressed air blast to remove loose material, mud and rebound from previously placed shotcrete. • Ensure L-shape T12 bar is anchoring the BRC mesh on to the slope surface with proper cover. • Check spacers for BRC mesh at 1m intervals. • Before shotcreting, the **horizontal drains and weep holes** shall be **plugged using polyfoam** to prevent ingress of shotcrete. • All weep holes shall have minimum 300mm embedded into the slope surface. • Thickness measuring pins (non-corrosive) shall be installed on 1.5m grids in each direction. • Check the thickness of measuring pins using normal ruler or measuring tape. > _____mm • The shotcrete shall be applied from the **bottom up** to prevent accumulation of rebound shotcrete on the slope surface to be shotcreted subsequently. • Nozzle shall be **perpendicular** to the slope about 1m – 2m away. Shotcreting with nozzle at angle deviated from normal axis to the slope surface which is more than 15^{o} is prohibited. • All shotcrete which lacks uniformity, exhibits segregation, honeycombing or lamination, or which contains any dry patches, slugs, voids or sand pockets shall be removed and replace with fresh shotcrete. • Carry out **1 test panel** 1.2mm x 1.2m x 0.2m (min. 6 cores) and send cores for testing at 7 days, 14 days and 28 days for every shotcrete of $100m^2$. All nozzle man must have produced at least 1 test panel for core test prior to production work. • Engineer reserves the right to request for coring at shotcrete surface or more test panels should there is doubt on the shotcrete quality. • Measure exposed portion of weep hole from shotcrete surface. > _____mm (>10mm)			
4.2	REMARKS:			

5.0	**SOIL NAIL HEAD**			
5.1	• Regardless of whether shotcrete face, grid beam system or individual nail head is adopted, the followings conditions **MUST** be complied: • The nail head (steel plate, bolt, nut, washer, etc) shall be **perpendicular** to the nail reinforcement. • A concrete pad perpendicular to nail reinforcement to be constructed **before** the nail head is installed. • Install nail head and tighten nut with torque wrench to the required torque of **200Nm**. • Casting of grid beam/head capping to be carried out only after Engineer inspected the completed nail head.			
5.2	REMARKS:			
6.0	**PULL OUT TEST**	**SIGNATURE**	**YES**	**NO**
6.1	List of Equipments • A single acting hollow hydraulic jack connected to hydraulic pump and pressure gauge. • A calibrated vibrating wire load cell • At least 2 (calibrated) dial gauges • Stopwatch to measure the period of observation			
6.2	General Procedures • The stressing equipment, pressure gauge and load cells should be calibrated by the manufacturer and in accordance with clause 10.6 BS 8081:1989. • The load cycle, load increments and minimum periods of observation shall be as instructed by the Engineer. • The setting-up of the pull-out test shall be submitted by the contractor and reviewed by the Engineer prior to the pull-out test.			
6.3	REMARKS:			
7.0	**DOCUMENTS FOR SUBMISSION**			
7.1	The following documents **MUST** be submitted to the Engineer for approval **1 week** before the commencement of any works at site: • Method Statement for soil nail works and shotcrete works including **photos** showing the size of drill bit/hammer for soil and rock. • Certificate of galvanising works from factory. (At least 5% of steel bars shall be tested according to BS729. At least 6 points shall be taken at the tested bar to measure the galvanise coat thickness. Average coat thickness**>85μm**.) • Specification of magnetic gauge to check minimum coat thickness of galvanise. (May be waived if approval obtained from Engineer) • Mill certificate of steel bars, steel welded wire fabric and galvanised soil nail reinforcement from factory.			

	• Mix proportion and water-cement ratio of non-shrink grout and shotcrete. • Specification of expansive additives and weight of additives required for every batch of mixing. • Specification of torque wrench for soil nail head. • Specification of threading, nut and washer details. • Test results of water (**MUST**) proposed for grout and shotcrete mixing in accordance to BS 3148:1990 or BS EN 1008:2002. • Sample of coupler/splicer together with the specification and test results (**MUST**). • Sample of centralisers/spacers for soil nail and BRC mesh. • Sample of geotextile, slotted PVC pipe (300mm length) with waterstop and endcap. • Sample of slotted/perforated weephole with endcap. • Setup details for soil nail pull out test. • Specifications and calibration certificates for hydraulic jacks, pressure gauge, load cell, dial gauges and strain gauges. • Machineries records. • Manpower records. • Soil nail installation records. (to be submitted after installation of each nail) No physical works shall be allowed to commence at site unless all above documents have been approved by the Engineer.			
	NOTE: **Once this copy is signed, the above guidelines have been clearly defined and understood by the contractor. Therefore, there shall be no problems in repeating the construction procedures for the soil nailing works without the presence of the Engineer's representative.**			