

1. GENERAL

- a) This works specification for guniting works covers all the resources and machine plus the technical requirements for guniting mix, machine and plant, surface preparation, method of operation, quality control and works acceptance criteria.

b) Method statement

The contractor shall prepare and submit method statement of guniting works to the SO/Engineer for prior **written approval** by at least 7 days before commencement of works.

The method statement shall contain:

- List of specific **machine**/equipment/tools (specific capacity/model, catalogue & photos) to be used,
- List of specific **materials**/products of specified quality (catalogues, test certificates & photos),
- List of **manpower**/key operator and technician (names with brief CV, experience & list of projects completed),
- **Sequence of works** (important sub-activities such as site inspection, pre-construction test panels, slope surface preparation, guniting, post-construction QC testing, etc., shall be included, machine & equipment layout in diagrammatic presentation, etc.),
- The estimated **daily output** to ensure the works can be completed within the scheduled work program required,
- Specified quality control tests/checks with respect to type and frequency plus their respective **acceptance criteria** shall also be included in the method statement, and
- **Remedial measures** shall also indicate in the method statement in cases where the acceptance criteria cannot be complied.

In brief, the Method statement shall clearly prescribe how the guniting work will be carried out with particular reference to sequence of works, realistic work output, quality control and resources requirements, etc., to ensure the guniting work can be completed within the stipulated or agreed time frame according to the specification and approved program. Method statement shall be prepared by experienced project manager/engineer who has extensive and intensive working experience and also is knowledgeable about the characteristics, capacity and efficiency of the resources available to his disposal. In addition, the project manager/engineer shall have inspected the site/surrounding conditions and studied the specification thoroughly before preparation of the statement.

c) Facilities for access to slope

Facilities/means of access to slope consisting of scaffolding/staging constructed of sound timber/bamboo, metal pipes or other materials agreed by the SO/Engineer shall be properly installed to enable the SO/Engineer to examine slope guniting works and proper access for the works to work. The scaffolding/staging shall allow access to within 0.8 m of the slope face. Hand and foot hold for climbing shall be provided by timber/bamboo or metal members at centres not exceeding 0.5 m vertically and 0.8 m horizontally.

A system of safety ropes shall be also installed on the scaffolding/staging. Safety ropes shall be 12 mm diameter and shall have a breaking force of at least 18 kN. The system of safety ropes shall consist of vertical ropes at not more than 3 m centres horizontally securely anchored to the crest of the slope, and horizontal ropes at not more than 3 m centres vertically. The system of safety ropes shall be constructed in such a manner that the ropes are tied at not more than 3 m spacings in both directions to form a net.

Protection fences and barriers shall be provided for the work areas.

- d) The Contractor shall carry out the guniting works as shown in the drawings and/or as directed by the Engineer. The Contractor shall apply gunite to the excavated slope surfaces at locations shown in the drawings or at locations directed by the Engineer.

“GUNITE” is a mixture of cement, sand or aggregate and water projected at high velocity from a suitable nozzle onto slope to produce a dense homogeneous protective layer. The maximum aggregate size shall be less than 10mm.

“Dry Process” is a mixture of cement, aggregate and sand weighted or calibrated volume batched, thoroughly mixed ‘dry’ and fed into a purpose-made machine where the mixture is suitably pressurized, metered into a dry air stream and conveyed through hoses or pipes to a nozzle before which water is introduced to hydrate the mix and is projected without interruption onto slope surfaces.

“Rebound” is a term used for all material having passed through the nozzle which does not conform to the definition of gunite as defined above. The rebound shall not be re-used and shall be removed from the site as soon as possible.

2. MATERIALS

a) Cement

Cement shall be Ordinary Portland Cement and comply with the requirements of M.S. 522.

b) Sand/aggregate

Sand or aggregate shall be clean and durable, and free from clay or organic matters and other impurities. The sand and aggregate shall be not more than 10mm and shall comply with the requirements of M.S. 29 and M.S. 30. The grading limits for the sand and aggregate mixture shall be as follows:

| | |
|--------------|------------------|
| 10.0mm sieve | 100 % passing |
| 5.0mm sieve | 90-100 % passing |
| 2.36mm sieve | 75-100 % passing |
| 1.18mm sieve | 55-90 % passing |
| 600um sieve | 35-59 % passing |
| 300um sieve | 8-30 % passing |
| 150um sieve | 0-10 % passing |

At least one sample from each sand supply source shall be taken for sieve tests to ensure compliance with the grading limits specified.

c) Water

Water for mixing shall be clean and free from harmful matter. Where tests are required they shall be in accordance with the requirements of M.S.28.

d) Reinforcement

Unless otherwise stated in the drawings steel fabric reinforcement shall be hard-drawn steel wire reinforcing fabric with wire diameter of 8.0mm pitch of 200mm in each direction (BRC A8) and comply with the requirements of M.S.145. Fabric reinforcement for gunite shall be fixed securely to the slope by steel nails or dowels and shall be laid without sharp bends or creases. The cover to the reinforcement shall be at least 25 ± 5 mm and laps between adjacent sheets shall be at least 150 mm. The fabric reinforcement shall be placed centrally in the gunite and be supported clear of the slope surface and away from all surface irregularities with adequate number of cover blocks.

e) Weepholes

Weepholes shall be upvc pipes of 50 mm diameter and shall be constructed:

- On soil surfaces at 1.5 m staggered centres in each direction, and
- On rock faces, on rock joints and at locations/spacings as directed by the Engineer.

All weepholes shall extend through the full thickness of the gunite and shall be laid with an outward inclination of 1 in 10.

f) Mix

The gunite shall have a minimum cement content of 350 kg per cubic meter and with water/cement ratio of not exceeding 0.5 by mass. Mix proportions shall be designed by the Contractor to achieve minimum **grade 30** or the specified grade of strength as shown on the Drawing and shall be approved by the SO/Engineer before commencement of works.

Mixture of dry aggregate and cement which are not applied on slope surface within 30 minutes after mixing shall be discarded.

Admixtures shall be added at 3-5 per cent by weight of cement to speed up the setting rate of cement, when directed by the SO/Engineer.

All constituents of the mix shall be uniformly dispersed throughout the mix. The technique and rate of application and all other factors affecting the quality of the gunite shall be adjusted to produce uniform, dense gunite with no sloughing.

3. QUALIFICATION OF OPERATORS

The Contractor shall certify or provide documentary evidence to the SO/Engineer on the satisfactory performances and experience of the intended foreman, nozzle man and delivery equipment operators for the guniting work.

Where required by the SO/Engineer, the guniting operators shall gunite preconstruction panels for the Engineer's assessment on skill and competence before acceptance of employment for the guniting works.

4. PLANT AND EQUIPMENT

Before commencement of work, the Contractor shall submit to the SO/Engineer for approval the type, make and number of plant and equipment to be used. A drawing showing the proposed plant and works arrangement with brief description about the equipment, the method of operation and mix proportion, etc., shall be included in the method statement as specified in Clause 1 (b).

5. PRECONSTRUCTION TEST PANELS

Before commencement of works, preconstruction tests panels shall be carried out to assess the suitability of equipment, technique and quality of guniting with respect to density, uniformity, thickness, strength, and works output rate to ensure the resources for guniting works can be carried out satisfactorily with respect to skill and quality.

Preconstruction testing shall be carried out using plant identical to that proposed for the works and shall be undertaken in such time before the commencement of the works to allow approval by the SO/Engineer.

Trial mixes of each mix design proposed shall be carried out by the Contractor. For each mix design, 3 number of test panels of minimum size 750mm x 750mm x 100mm thick shall be sprayed from each position required in the works, such as down-hand, vertical and overhead positions, with layer thickness appropriate to that position. Panel moulds shall be formed from 20mm thick plywood adequately braced and held rigidly in position.

6. INTERFACE PREPARATIONS

- a) Earth or natural surfaces other than rock shall be compacted, trimmed, graded and cleansed (free from loose/soft/organic materials/debris) according to the design grade before guniting. Weak material along relict joints or seams in slope surfaces to which gunite will be applied shall be removed to a depth equal to the width of the weak zone.
- b) The newly excavated or trimmed slope shall be immediately and adequately protected against infiltration by immediate guniting or protected by tarpaulin sheet or other method approved by the SO/Engineer. The earth surface shall be maintained at equilibrium moisture, as directed by the SO/Engineer (not too wet or too dry before guniting). Gunite shall **NOT** be applied on surfaces with any loose or soft or wet materials. Wet surface (after rainfall) shall be covered by tarpaulin for at least 2 days or until the surface moisture has moisture content within the natural moisture content $\pm 2\%$ or as directed by the SO/Engineer. Slope surface conditions just before guniting shall be captured with labels to indicate locations for record and QC purposes.
- c) Rock surfaces shall be cleansed and free from any loose materials, mud or foreign matters. After cleansed by compressor or washing down with water, the rock surfaces shall be damp but exhibiting no free water prior to guniting.
- d) Where flow of water interferes with the application of gunite or cause leaching of cement, the flowing water shall be directed by appropriate drainage channels to convenient locations where plugging can be carried out.
- e) The reinforcement shall be cleansed and free from loose mill scale, loose rust, oil or other coating prior to the application of gunite. All reinforcement shall be stored under cover and clear of the ground. Any reinforcement that is pitted with rust shall be rejected. The reinforcement fabric shall be securely and firmly fastened with the dowels shown on the drawing and supported with approved spacers at about 1.6m centre to centre spacing to provide 30mm to 40mm clearance cover between the fabric and the slope surface.

7. NORMAL GUNITING PROCEDURE

- a) Before starting work, the Contractor shall submit to the SO/Engineer for approval a detailed schedule of the entire guniting operation and method statement of works as per Clause 1 (b). Approval of such schedule and method statement shall not relieve the Contractor of his responsibility to provide a fully satisfactory installation. The Contractor shall include with his submission evidence that he has successfully completed a gunite installation using the procedures similar to those proposed.
- b) All reinforcement shall be securely and firmly fixed with the dowels, weep-holes and spacers to give the required cover, clearance or lap as described or specified. Guniting shall be commenced from the top or upslope downwards to ensure no ingress of runoff below the gunite. Guniting shall be carried out by directing the nozzle perpendicularly ($1.5\text{m}\pm 0.3\text{m}$) to the surface to be gunited.
- c) Guides shall be set-up to establish good finish surfaces. Gunite shall only be applied in the presence of the SO/Engineer or his representative and shall be built up in successive layers, each layer generally not exceeding 50mm in thickness, such that sagging and bleeding do not occur. Each panel dimension shall not exceed 20 m^2 . Gunite shall be applied evenly without any sags or slumps. All reinforcement shall be completely surrounded by gunite. Whenever the spraying operation becomes irregular, the nozzle shall be directed away from the works area and all spraying shall stop. The nozzleman shall not step on the BRC before the gunite has set during guniting, but shall stand on staging.
- d) Colour pigment cement (ASTM C979), if specified in the drawing or directed by the SO/Engineer shall be mixed thoroughly with the gunite mix. A layer of 25 mm thick of the coloured gunite shall be applied to form the total thickness of gunite stated in the Drawing.
- e) The Contractor shall be required to monitor closely the progress of the guniting works. Daily site records of all materials delivered to the gunite mixer shall be properly maintained and made available to the SO/Engineer when required. Sand shall be covered by tarpaulin sheet to prevent from wet by rain.
- f) All gunite shall be cured continuously for at least 4 days or by approved curing compound or equivalent.

8. REBOUND

All rebound and loose materials shall be removed by air jets or other means from the surface of each layer as work proceeds. Rebound shall not be worked into the sprayed area or re-used in the works.

All surfaces which are not to receive gunite shall be protected by approved methods.

9. CONSTRUCTION JOINTS

The type and positions of all construction joints shall be approved by the SO/Engineer. Construction joints shall be formed by placing or trimming the sprayed gunite layer to an angle of approximately 30 degrees.

10. WORKS TEST PANELS

During the progress of the works, the Contractor shall provide at least three moulds for reinforced test panels of size 750mm x 750mm x 100mm thick, rigidly fixed alongside the works at locations as required by the Engineer. The moulds shall be sprayed at such time from such concrete batches and by such personnel as the engineer may direct. The test panels shall be stored and cured alongside the guniting works and under similar conditions.

11. WEEPHOLES

Before starting works, the Contractor shall submit to the SO/Engineer for approval a detailed proposal for the construction of weepholes. The location and spacing of weep holes shall be as specified in 2 (e) and as shown on drawings.

12. BAD WEATHER

Guniting shall be stopped if encountered by bad weather conditions e.g. rain, high winds, high waves, etc. The freshly guniting surface (<3hrs) shall be protected by tarpaulin sheet. The guniting work shall only be resumed when conditions are satisfactory and acceptable for guniting work. Any damaged guniting shall be replaced by the Contractor on the account of the Contractor and no extra claims will be considered.

13. QUALITY CONTROL**a) Method Statement**

Method statement as specified in Clause 1 (b) shall be submitted by the Contractor for SO/Engineer approval as part of QC before commencement of works.

b) At least 9 cubes of each **trial mix** shall be carried out to check the strength of the mix specified on contract drawings. Rebound hammer test also has to be carried out on preconstruction test panels at locations selected by the SO/Engineer (at least 9 points/panel). The Contractor has to redesign the mix and change equipment or nozzleman if the results of any cube or any rebound hammer test are below the specified strength on the drawing.

c) For every 200m² of completed guniting works or as directed by the SO/Engineer at guniting surfaces with sagging/bleeding or inconsistent colour or at joint, a series of rebound hammer test (30 test point per series) has to be carried out to verify the strength (28 days strength). The SO/Engineer reserves the right to reject the guniting work if the average test result is below the specified strength.

d) All the weep holes shall be marked by red paint to show the required effective thickness of guniting specified on drawings.

e) Prior spraying of guniting, the Contractor shall request inspection by SO/Engineer and a photo (minimum one photo for every 200m²) shall be taken to show the thickness markings. In addition to the markings, coring to check the quality/porosity and thickness of guniting shall be subsequently carried out. Coring (50mm diameter) shall be at a rate of one core per 200 m² or less at locations selected by the SO/Engineer for checking the **thickness and quality** of guniting (**free from void/honeycomb, appropriate cover** for wire-mesh, unconfined compression **strength** more than as

specified and density more than 22 kN/m^3). The drilled holes shall be backfilled with dry-packed compressive (1:3) mortar. Documental evidence by photo for each core shall be carried out. The SO/Engineer reserves the right to reject the guniting works if the thickness of guniting is found inadequate or the guniting is found porous or low strength (less than the specified value). Further coring (one core per 200m^2) shall be carried out at Contractor's own costs if any defective works are detected. The localized areas which in the opinion of the SO/Engineer are substandard or hollow shall be removed and re-guniting. Core holes shall be reinstated with cement mortar of colour matching the adjacent surfaces.

- f) In case of global defective guniting works, the Contractor shall engage a qualified professional engineer with comparable experience to study and propose rectification works, when defective works are identified and directed by the SO/Engineer. The Contractor is fully responsible for all the costs, time delay in works and other incidental consequences/costs for the defective works. The proposed rectification works, if accepted by the SO/Engineer, shall be carried out at the Contractor's own costs.
- g) Records of guniting operations shall be kept by the Contractor on the Site and shall be submitted daily to the SO/Engineer. The records shall contain date and areas completed daily, details of the quantities of all materials used at each panel/location plus locations of coring tests with test results. The records could be a hard copy and soft copy in format as agreed by the SO/Engineer. The soft copy shall be in read-only format and the hard copy shall be double side printed as agreed by the SO/Engineer.

14. RIGHT TO REJECT DEFECTIVE GUNITING PLACED

The SO/Engineer reserves the right to reject any of the defective guniting placed under any of the following conditions and for any other conditions deemed unsatisfactory:-

- Guniting without the prior inspection/approval of the SO/Engineer and/or without photos captured to show the slope surface conditions just before guniting,
- Inadequate cleaning or preparation of the surface to be guniting,
- Guniting damaged (sloughing/sagging/cracks) during placing and/or inadequate batching,
- Guniting layer which has been placed over improperly or inadequately cleaned or set preceding layer,
- Failure to meet any of the requirements of this specification and/or standards included in this specification,
- Presence of pockets or voids or porosity in guniting structures,
- Guniting surface is of a thickness less than that shown on the drawings, and
- Failure to meet any QC tests.

All necessary rectification or reworking shall be carried out by the Contractor at his own expense all to the satisfaction of the SO/Engineer.

15. MEASUREMENT & PAYMENT

The works measured shall be measured as given in BQ and shall be paid for at the Contract unit price as detailed in the Bill of Quantities. This payment for accepted work done shall be for full compensation for all work, materials, plant, equipment and tools, described in this Section of the Specification and shall include for: -

- (a) To provide all necessary resources including plant, equipment, tools, materials, manpower/labour and all incidentals necessary to complete the scope of guniting works in accordance with the drawings and Specification,
- (b) Slope surface trimming, cleansing and preparation to receive gunite,
- (c) Environment protection and cleaning of site as specified,
- (d) Carrying out of pre-construction panels and trial mixes, design mixes of gunite and cube testing,
- (e) To provide all necessary reinforcing dowel steel bars including cutting, bending, placing, fixing and supporting, for splicing and welding and wastage of steel reinforcement,
- (f) To provide & erect all necessary temporary staging, scaffolding, formwork and temporary structures necessary for the works,
- (g) Construction of all joints, beddings, etc., for gunite ,
- (h) Supply and installation of weepholes as specified. Making openings, chamfers, holes, chases, etc. in the gunite structures,
- (i) Curing of gunite, and
- (j) QC tests as specified.

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