HIGHWAYS DEPARTMENT

GUIDANCE NOTES

ON

USE OF SELF-COMPACTING BACKFILL MATERIAL

Research & Development Division

RD/GN/049
September 2022

Contents

1. Introduction

1.1 Controlled low-strength foamed concrete (CLSF Concrete) was introduced in Highways Department (HyD) Guidance Notes No. RD/GN/014D on Permanent Trench Reinstatement for use as an alternative backfilling material in lieu of soil for backfilling utility trenches under public roads maintained by HyD to overcome some difficult underground situations, such as trenches with congested utilities, where backfilling or compaction of soil cannot be conducted satisfactorily and thus causing unsatisfactory permanent reinstatement of the pavement above. Due to the low thermal conductivity of CLSF Concrete, it was not suitable for use at utility trenches with power cables installations.

1.2 In April 2020, Nano and Advanced Materials Institute Limited (NAMI), with HyD's support, completed a research study funded by the Innovation and Technology Fund and the Construction Industry Council to develop an alternative self-compacting backfill material (SCM) in lieu of soil for backfilling utility trenches with power cables installations. This newly developed backfilling material is designed to achieve some intended engineering properties (i.e. high flowability, fast set, low strength and high thermal conductivity) to address difficulties encountered in backfilling all types of utility trenches, including trenches congested with power cables which are quite common in Hong Kong. With the successful development of those intended engineering properties, this newly developed material will improve the quality of utility trenches backfilling works and hence will help to reduce the number of unsatisfactory road reinstatement arising from improper compaction of the soil underneath the road pavement.

1.3 Subsequently, a number of site trials on the use of SCM for backfilling utility trenches under a collaboration study between Research and Development (R&D) Division of HyD and NAMI have been conducted in the period between 2020 and 2021 with a view to expediting the commercialization of SCM. In the above study period, SCM has also been used as a trial for backfilling voids between underground structures (including pile cap and underpass wall) and their temporary lateral support under the Central Kowloon Route project of HyD. Findings of the above further site trials demonstrated that SCM has the properties and benefits as summarized in **Appendix 1**.

1.4 Particular specification (PS) for use of SCM as an alternative backfill material for utility trenches and voids was circulated to various Works Departments and utilities undertaking (UU) members of Utilities Technical Liaison Committee / Joint Utilities Policy Group in January 2022 to facilitate any interested parties to use SCM under their contracts if considered suitable and appropriate. A sample of the PS is enclosed in **Appendix 2**. The purpose of this set of guidance notes is to provide guidelines on the use of SCM under public roads and streets maintained by HyD.

2. Applications of Self-compacting Backfill Material (SCM)

2.1 Based on the successful completion of the research study and site trials mentioned above, the following works are considered suitable in general to use SCM as an alternative backfill material in lieu of soil/conventional backfill material:

a) backfilling of utility trenches; and

b) filling voids in the following areas where difficulties are experienced in achieving desirable performance of backfilling or compacting conventional backfilling material (i.e. soil) in a timely manner, and thus may cause unsatisfactory permanent reinstatement of the pavement above:
   (i) between pile caps and temporary lateral supports;
   (ii) between manholes, gully pits, gully sumps, other drainage chambers and temporary lateral supports; and
   (iii) between underpass wall without permeable drainage and temporary lateral supports.

3. Consent Requirement from Utilities Undertakings (UUs)

3.1 In general, SCM to be used for backfilling shall be a mixture of fine aggregates, pulverized material, admixtures or additives, water and a small amount of cementitious material and has engineering properties of high flowability, fast set, low strength and high thermal conductivity[1]. The potential advantages associated with the properties of SCM include: less on-site labour and equipment requirements (due to its flowable nature and easy placement with no vibration needed); fast construction speed (from order, delivery of materials to clean up); and controlled low-strength that allows easy re-excavation, yet is strong enough for backfilling needs and support of the pavement above.

3.2 While SCM has various advantages, there are concerns as expressed by UUs on the use of the material, such as (i) SCM may flow into cracked pipes or ducts; (ii) the thermal conductivity of SCM may drop with lower water content; and (iii) SCM takes time for hardening and is not as easy as soil to be re-excavated. To strike a balance between UUs' concerns and fostering development on use of innovative material for avoiding unsatisfactory road reinstatement and reducing overall construction time where compaction of soil is difficult to be carried out, project proponents shall note the following matters for actions if they propose to use SCM as an alternative backfill material to backfill utility trenches/voids with embedding existing underground installations exposed within the backfilling area:

a) Seek written consent from the UUs concerned whose existing underground installations will be embedded by SCM;
b) Prior to placement of SCM, the project proponent shall check to ensure that all ducts and pipes to be embedded with SCM are in good conditions. In case of doubt, the project proponents shall consult the UUs concerned; and
c) Cracks/holes in existing utilities pipes/ducts should be sealed by appropriate materials/means (subject to agreement by the UUs concerned) before placing of SCM.

4. Technical Guidance and Administrative Measures on Use of SCM

4.1 SCM may be ordered from material suppliers with capability to produce SCM meeting the acceptance criteria as given in Table I below and it shall be produced at their mixing plant. Mixing SCM using pre-packed materials on site is in general not allowed.

4.2 The bottom of the utility trench/void to be backfilled with SCM shall be in relatively dry

[1] The thermal conductivity of SCM will vary with different water content of the material.

condition and SCM shall not be used in locations of steep gradients due to its high flowability and self-leveling properties.

4.3 The project proponent shall allow a sufficient period of temporary occupation of the site to allow SCM to set and to achieve sufficient initial strength to take the loading of the footway/carriageway pavement or surfacing materials above, and the subsequent traffic/pedestrian loading. In view of potential hazard in terms of drowning at early stage after the placing of SCM, the project proponent shall ensure that the backfilled utility trench/void is properly fenced off before setting of SCM and subsequent application of the pavement or surfacing materials above.

4.4 Floating of light weight cables/pipes should be avoided by ensuring appropriate ties/weights are attached to the relevant existing underground utilities installations during the placing of SCM.

4.5 Samples of SCM shall be collected from the site and tested. The relevant testing arrangement and compliance requirement shall refer to PS in **Appendix 2**.

4.6 The project proponent shall seek comments from Regional Offices of HyD for SCM proposed to be used as alternative backfill material for utility trench/void under public roads/streets maintained by HyD. Written consent by the UUs concerned (if their existing underground installations are to be embedded by SCM) and/or LCSD (if the proposed use of SCM for backfilling would affect nearby trees) shall be provided.

4.7 After placement of SCM, the project proponent shall submit the following information to Regional Offices of HyD when handing over the relevant public roads/streets maintained by HyD:

a) record photographs of the utility trench/void before and after backfilling with SCM;
b) the original or certified true copy of the test certificate/report of SCM proving that the performance of the placed SCM meeting the compliance requirements; and
c) as-built plan where the SCM is applied including area, length, width and depth in both pdf and shp format.

R&D Division of HyD would collect as-built plans of SCM on a regular basis for subsequently uploaded to the XPMS for the reference of UUs and other parties concerned.

4.8 If the 28 days compressive strength of the proposed SCM is subsequently found to be exceeding 1 MPa (for utility trench backfilling) or 2 MPa (for other voids backfilling), the project proponent shall be required to propose rectification measures such as manual excavation of spare SCM bulk sample prepared from the same batch of SCM used in the backfilling works to demonstrate that the hardened non-compliant SCM can still be excavated with hand tools without sharp edges to the satisfaction of the Regional Offices of HyD and the UUs concerned (if any) in case that their existing underground installations are embedded by the non-compliant SCM. Subject to agreement by HyD and the UUs concerned (if any) on such demonstration, the hardened non-compliant SCM is not required to be removed. Otherwise, HyD may require the project proponent to remove the non-compliant SCM with appropriate agreed method (e.g. using hand tools), backfill the utility trench/void with conventional backfill material and then reinstate the pavement/surface above. The proposed rectification measures and arrangement shall be

included when the project proponent seeks consent from UUs on the proposal to use SCM as required in paragraph 3 above.

4.9 If existing SCM needs to be excavated due to works in the future, there is no mandatory requirement for using SCM again to backfill the excavated area which may consist of hardened SCM. Project proponents shall consider using suitable backfilling material for their works.

Table I - Acceptance Criteria for SCM

No.	Test	Testing Standard	Acceptance Criteria
1.	Density	CS1: 2010, Section 5	Between 1900 to 2100 kg/m^3
2.	Flowability	ASTM D6103	Slump flow spread (without segregation) $\geq$200 mm
3.	Hardening Time[2]	CS1: 2010, Section 3	Time from completion of mixing to reach penetration resistance with final set (3.5 N/mm^2), within 8 hours to 24 hours
4.	Initial Strength	ASTM D6024	If no surface water and no indentation with diameter larger than 75 mm is observed after the ball-drop test, the hardened SCM is considered ready for load application
5.	Compressive Strength (28 days)[3]	CS1: 2010, Section 12	Not less than 0.3 MPa and not more than 1 MPa (for utility trench backfilling) or 2 MPa (for other void backfilling)
6.	Thermal Conductivity (For backfilling utility trench)	ASTM D5334	>1.1W/mK when moisture content >10%

[2] This test is not to be included in the Particular Specification for SCM for actual backfilling works but is required from material supplier to demonstrate that the proposed SCM can meet the setting time requirement.

[3] Due to the low compressive strength of SCM, the loading rate of the compressive strength testing machine shall be adjusted to suit.

Technical Information of Self-compacting Backfill Material (SCM)

Self-compacting backfill material (SCM) is a low strength but highly flowable alternative backfill material when compared with soil/conventional backfill material. Application of SCM as an alternative backfilling material will provide a solution to overcome some difficult underground situations, such as trenches with congested utilities, where backfilling or compaction of the conventional backfilling material cannot be conducted satisfactorily and thus causing unsatisfactory permanent reinstatement of the pavement above.

Properties and Benefits of SCM:

- High flowability - easy for backfilling congested space such as void underground or space between pipes/cables;
- Self-leveling and self-compacting – no need for compaction/vibration during placing, thus shorten the overall backfilling time when comparing with compaction of soil in layers;
- Fast setting – allow application of the surfacing material shortly after it is hardened;
- Suitable for pumping - overcome site access difficulties;
- No settlement/consolidation after hardening;
- Fast construction speed;
- Low strength - easy for future re-excavation;
- High thermal conductivity - heat dissipation for underground power cables; and
- Readily available – can be ordered from a number of ready mix concrete suppliers.

Technical Specification of SCM:

Density	Between 1900 – 2100 kg/m^3
Flowability	≥ 200 mm (without segregation)
Compressive strength (28 days)	Not less than 0.3 MPa and not more than 1 MPa (for utility trench backfilling) or 2 MPa (for other void backfilling)
Hardening time	Time from completion of mixing to reach penetration resistance with final set (3.5 N/mm^2), about 8 to 24 hours
Thermal conductivity	> 1.1 W/mK, when moisture content is > 10%

SAMPLE PARTICULAR SPECIFICATION

SELF-COMPACTING BACKFILL MATERIAL FOR BACKFILLING UTILITY TRENCHES AND VOIDS

(a) GLOSSARY OF TERMS FOR SELF-COMPACTING BACKFILL MATERIAL

(1) Self-compacting backfill material (SCM) shall be backfill material using cementitious material, fine aggregate, pulverized material, water and admixtures for controlling the rheology and setting time of the in-situ material.

(2) This PS for use of self-compacting backfill material (SCM) shall apply when so ordered by the Engineer.

(b) MATERIALS

(1) Cementitious material shall be Portland Cement (PC) to BS EN 197-1:2011 or Pulverized Fuel Ash (PFA) to BS EN BS EN 450-1:2012.

(2) Fine aggregate shall be clean and hard complying with CS3. Natural sand shall not be used unless with the prior agreement of the Engineer.

(3) Pulverized material shall be clean sedimentary rock material with the following requirements:

(a) grain size of no more than 100 μm;

(b) the clay content, determined by the methylene blue test in accordance with BS EN 933-9:2009 shall not exceed 1.50g/100 g; and

(c) Calcium carbonate ($CaCO_3$) content calculated from the calcium oxide content in accordance with BS EN 196-2:2013 shall be at least 75 % by mass.

(4) Admixtures shall comply with the following: BS EN 12878:2014 for pigments, BS EN 934-2:2009+A1:2012 for accelerating admixtures, retarding admixtures, water-reducing admixtures and superplasticizing

admixtures.

(5) Water shall be clean fresh water taken from the public supply. Non-saline water from other sources may be used subject to the Engineer's approval, provided that it can be demonstrated that the water is neutral in PH value, free from suspended solids and liquid contaminants non-miscible with water. It shall be tested and comply with BS EN 1008. Wash water from concrete mixer washout operations (recycled water) shall not be used.

(c) SUBMISSIONS

(1) The following particulars of the proposed cementitious materials, fine aggregate and pulverized material shall be submitted to the Engineer for approval at least 14 days before the SCM is placed in the backfilling area:

(a) Certificate not older than 6 months for each type of cement or PFA showing the manufacturer's name, the date and place of manufacture and showing that the cement or PFA complies with the requirements stated in the Contract and including results of tests for composition;

(b) Certificates/documents not older than 6 months for fine aggregate in accordance with Clause 6.2.2 (2) of CS3 showing the compliance of requirements as stated in the Contract; and

(c) Certificates/documents not older than 6 months for pulverized material showing the compliance with the requirements stated in the Contract and including results of tests for grain size, methylene blue value and calcium carbonate content.

(2) The following particulars of the proposed admixtures shall be submitted to the Engineer for approval at least 14 days before the SCM is placed in the backfilling area:

(a) Manufacturers' literature, description of physical state, colour and composition, recommended storage conditions and shelf life;

(b) Method of adding to the SCM mix, recommended dosage, effects of under-dosage and over-dosage; and

(c) A certificate not older than 6 months for each type of admixture showing the manufacturer's name, the date and place of manufacture and showing that the admixture complies with the requirements stated in the Contract.

(3) The following particulars of each proposed designed SCM mix shall be submitted to the Engineer for approval at least 14 days before the SCM is placed in the backfilling area:

(a) Grading of fine aggregates;

(b) Method of placing the SCM; and

(c) Source, formulation, test data for designed mix SCM produced in the plant or plants and test reports of site trials for designed mix SCM proposed to be use including results of tests required in Clause (i) conducted on the site trial samples to demonstrate the appropriateness of their SCM formulation meeting the criteria.

(4) The following particulars of the proposed production facilities shall be submitted to the Engineer for approval at least 14 days before the SCM is placed in the backfilling area:

(a) The name of the suppliers and the location of each plant, including a back-up plant and calibration frequency of equipment, from which the Contractor proposes to obtain SCM; and

(b) Particulars of the proposed batching and mixing plant to be used on the Site, including a layout plan and the output of the plant.

(5) The following particulars of the proposed placement methods of SCM shall be submitted to the Engineer for approval at least 14 days before the SCM is placed in the backfilling area:

(a) Before SCM reaching its initial set and providing sufficient load bearing capacity in the first several hours after placement, the Contractor shall provide a plan to show how to fence off the backfilled area properly before subsequent application of the surfacing materials

above.

(d) BATCHING AND MIXING

(1) Measuring and weighing equipment for batching SCM shall be maintained in a clean, serviceable condition. The equipment shall be zeroed daily and calibrated at a frequency provided in the submission under Clause (c)(4). The accuracy of the measuring equipment shall be within 3% of the quantity of cementitious materials, total aggregates or water being measured and within 5% of the quantity of admixtures being measured.

(2) The quantities of cementitious materials, fine aggregate and pulverized material shall be measured by mass. The mass of aggregates shall be adjusted to allow for the free moisture content of the aggregates.

(3) Separate weighing equipment shall be used for cementitious material.

(4) The quantity of water shall be adjusted for the free moisture content of the aggregates and shall be measured by mass or volume.

(5) Liquid admixtures shall be measured by mass or volume and powdered admixtures shall be measured by mass.

(6) The quantities of SCM mixed and the speed of operation of a mixer shall comply with the supplier's recommendations.

(7) A mixer shall not be loaded in excess of its rated capacity and shall be emptied before being re-charged. A mixer that has been out of use for more than 30 minutes shall be cleaned before fresh SCM is mixed in it.

(8) Mixer shall be thoroughly cleaned before mixing fresh SCM in it, if mixer has been used to mix concrete.

(9) Mixing time or the number and rate of revolutions of mixer drums shall not be less than those recommended by the supplier unless it is demonstrated in the production of SCM that a shorter time or fewer or slower revolutions are adequate. Constituents shall be thoroughly mixed and admixtures shall be uniformly distributed throughout the SCM.

(10) Water shall be added to truck mixed SCM at the batching plant and shall not be added in transit. Water shall not be added at the Site.

(e) TRANSPORTATION OF SELF-COMPACTING BACKFILL MATERIAL

(1) SCM shall not be transported in a manner that will result in contamination, segregation, loss of constituents.

(2) SCM batched off the Site shall be transported to the Site in purpose-made agitators operating continuously or in truck mixers.

(3) Truck mixers transporting the SCM shall be thoroughly cleaned before loading and transporting fresh SCM.

(f) RECORDS OF SELF-COMPACTING BACKFILL MATERIAL

(1) Delivery notes shall be provided for each delivery of SCM to the Site. The delivery notes shall be kept on the Site and shall be available for inspection by the Engineer at all times. Delivery notes shall contain the following details:

(a) Serial number of delivery note;
(b) Date;
(c) Name and location of batching and mixing plant;
(d) Registration number of delivery vehicle;
(e) Name of purchaser;
(f) Name and location of the Site;
(g) Designation of SCM mix;
(h) Sources of cementitious materials and fine aggregate;
(i) Quantity of SCM;
(j) Time of introduction of water to the SCM; and
(k) Source, formulation and proprietor of SCM mix

(2) Records of backfilling operations shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer at all times. Records shall contain the following details:

(a) Date;

(b) Designation of SCM mix;
(c) Total quantity of each SCM mix produced that day;
(d) Serial number of delivery note;
(e) Arrival time of delivery vehicle;
(f) Time of completion of discharge;
(g) Position where SCM is placed;
(h) Results of flowability tests;
(i) Details of test cubes made for compressive strength tests;
(j) Details of test samples made for hardening time tests, and
(k) Details of testing locations for initial strength tests and thermal conductivity tests.

(g) PLACING OF SELF-COMPACTING BACKFILL MATERIAL

(1) The permission of the Engineer shall be obtained before SCM is placed in any part of the permanent works. If placing of SCM is not started within 24 hours of permission having been given, permission shall again be obtained from the Engineer. The Contractor shall inform the Engineer before backfilling starts and shall allow the Engineer sufficient time to inspect the backfilling works.

(2) Fresh SCM shall be placed in its final position within 2½ hours of the introduction of water to the SCM mix.

(3) Additional protective sheets shall be used around the discharging area to avoid any splashing of SCM. In addition, trunking or chutes shall be used to place SCM which will fall more than 2.7 m to further control the splashing unless otherwise permitted by the Engineer. Trunking or chutes, where being used, shall be clean and used in such a way to avoid segregation and loss of constituents of the SCM.

(4) SCM shall be placed in horizontal layers in a manner that non-permanent components of lateral support can be removed after placement.

(5) SCM can be placed with concrete pumps, which shall be operated and maintained in accordance with the supplier’s recommendations. The pumps and pipelines shall be maintained in a clean condition. Joints in pipelines shall be tightly fixed and shall not permit grout loss.

(h) TESTING AND SAMPLING

(1) The sampling of fresh SCM shall be done according to CS1:2010 Section 1 where samples are collected from first batch and from subsequent batches after discharge of every or less than 25 cubic meters. Samples are collected from the first vehicle delivering the SCM in the above batches. The number of tests for flowability, density of fresh SCM, compressive strength of SCM may be reduced if in the opinion of the Engineer the standard of quality control is satisfactory.

(2) The density of fresh SCM shall be tested according to CS1 Section 5 where two samples are collected from a batch.

(3) The flowability of the SCM shall be tested according to ASTM D6103 or equivalent, where two samples are collected from a batch. The flowability shall be tested from every batch before placement of the backfill.

(4) Two samples are collected from a batch for determination of compressive strength after 28 days, where a pair of testing cubes shall be made from each sample. The size of test cube shall be 100 mm and the method of making test cubes shall be in accordance with CS1. The method of testing shall be in accordance with CS1.

(5) The load placement capability of the SCM surface shall be tested according to ASTM D6024 or equivalent prior to further backfilling or conducting other works over the SCM backfilled area. The Engineer shall appoint a representative testing location, where the load placement test shall be conducted of 5 consecutive times for every 20 m^2 of the in-place SCM or part thereof.

(6) The thermal conductivity of the SCM shall be carried out when backfilling utility trench with power cables and tested according to ASTM D5334 or equivalent. The Engineer shall appoint no less than 5 locations within the backfilled area for every 20 m^2 of the in-place SCM or part thereof, where the thermal conductivity test shall be conducted.

(i) COMPLIANCE CRITERIA

(1) The compressive strength of the SCM at 28 days shall be not less than 0.3 MPa and not more than 1 MPa (for utility trench backfilling) or 2 MPa (for other void backfilling).

(2) The density of fresh SCM shall be in range of 1900-2100 kg/m^3.

(3) The flowability of the SCM shall be no less than 200 mm without segregation according to ASTM D6103.

(4) The indentation diameter of 5 measurements under the load placement capacity test shall be no more than 75 mm and is considered ready for placement of subsequent layers and open to traffic.

(5) 5 measurements under the thermal conductivity test shall be greater than 1.1W/mK when moisture content >10%.

(j) NON-COMPLIANCE

(1) If the result of either the flowability or density carried out on a sample taken from the first vehicle of the batch does not comply with the specified requirements for workability and density, the SCM in that vehicle shall not be placed in the backfill area. Another sample from the subsequent vehicle of the same batch shall be collected for testing the flowability and density until complying with the requirement.

(2) If the 28 days compressive strength of the proposed SCM does not comply with the specified requirements, the Contractor shall be required to propose rectification measures such as manual excavation of spare SCM bulk sample prepared from the same batch of SCM used in the backfilling works to demonstrate that the hardened non-compliant SCM can still be excavated with hand tools without sharp edges to the satisfaction of the Engineer and Utility Undertakings if their existing installations are embedded by the non-compliant SCM such that hardened non-compliant SCM is not necessary to be removed. The proposed rectification measures and arrangement shall be included under consent requirement in Clause (k) below.

(3) If indentation diameter after the five measurements under the load placement capability test does not meet the acceptance criteria, an additional load

placement test in the vicinity of the non-compliant testing location shall be conducted at appropriate intervals, such as hourly until the acceptance criteria are met such that works over the backfilled area can be resumed.

(4) If any of the five measurements under the thermal conductivity test does not comply with the specified requirements, the Contractor shall remove the hardened non-compliant SCM, backfill the trench and reinstate pavement above with appropriate method agreed with the Engineer.

(k) CONSENT REQUIREMENT

(1) Prior to placement of the SCM, consent from existing underground installations owners should be available if their existing underground installations will be embedded by the SCM.