APPENDIX C

PROJECT SPECIFICATION FOR THE APPLICATION OF A STABILISING AGENT (END PRODUCT SPECIFICATIONS) TO BE USED TO IMPROVE THE BEHAVIOUR OF ROAD CONSTRUCTION MATERIALS, INCLUDING:

- NANO-MODIFIED EMULSION (NME) OR SIMILAR;

- NME WITH POLYMERS;

- POLYMERS, AND

- ANY OTHER ADDITIVE.

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PROJECT SPECIFICATIONS

PART C COLD IN-SITU STABILISATION WITH A NANO-MODIFIED EMULSION (NME) STABILISING AGENT

CONTENTS

C1001 SCOPE

This section covers work required for construction of new roads or for the rehabilitation of the upper pavement layers (base and sub-base) using the cold insitu recycling process with (a) conventional equipment, (b) recycler and (c) central mixing plant. The

construction of new pavement layers using an appropriated NanoModified Emulsion (NME) stabilising agent or alternative stabilising additive/product is aimed at the use of naturally available materials from the area of the road that can cost-effectively be utilised in the upper pavement layers.

The rehabilitation of existing roads are aimed at the optimum use of damaged or weathered in-situ materials in a cold in-situ recycling process which may include a pre-stabilisation process of the breaking up of existing pavement layers and mixing of the materials, with or without the addition of new material to achieve a uniformly mixed material with no materials exceeding the least maximum size of 63 mm or a third the total thickness of the layer that are being recycled. After a homogeneous mix has been achieved, the material is in-situ stabilised with the applicable NME stabilising agent or alternative stabilising additive/product to produce a homogenous mixture, which is spread, cut to level and compacted to the required specification.

This section further covers the use of applicable prime, as a temporary surface for early trafficking.

C1002 MATERIALS

The use of an appropriate NME stabilising agents or alternative stabilising additive/product aims to optimally use naturally available material (new or in-situ) in the upper pavement layers of a road meeting the minimum design requirements as specified in Table C1002/1 (to be applied during construction for quality control) and C1002/2 (to be applied during the detailed material design in the laboratory). The aim is to cost-effectively utilise naturally available materials as an alternative to newly crushed stone materials in both the design and construction of new roads as well as the rehabilitation of existing pavements through the improvement (through neutralisation of the effect and possible negative impact of secondary minerals due to weathering) of available materials normally considered to be “non-standard”, “marginal”, “low-cost”, or even “sub-standard” in terms of the standard material indicator tests developed empirically more than century ago.

Materials from existing pavement layers shall be classified as follows for excavation and processing purposes:

(i) Existing bituminous material

Bituminous surfacing shall be asphalt surfacing and bituminous seal from the existing layers. Where the asphalt surfacing and bituminous seal are recycled together with the underlying layers, the mixture will **not** be classified as bituminous material.

(ii) Granular material

The base and sub-base pavement layers in the existing pavement shall be classified as granular materials.

Granular material shall include crushed stone gravel soil and natural gravel and can consist of cemented or non-cemented material. Crushed stone obtained from existing pavements and processed as gravel material will be paid for as gravel material and not as crushed stone.

The mixture of bituminous material (RA) and base and sub-base material shall be classified as granular material.

(iii) Extra material

Extra material as specified consists of:

(a) Naturally available materials (and (if cost-effective) crushed stone materials)

The pavement layers will be designed based on the requirements of the design traffic loadings and the material specifications required for the various pavement layers as designed, complying with Table C1002/2.

(b) Crusher dust.

No crusher dust is to be used with NME stabilising agents.

(c) Gravel.

The gravel material shall be of G5 to G8 type as per table C1002/1. (Material of a higher quality may also be improved or protected against chemical weathering, normally requiring less additives/modification depending on the inherent mineralogy.)

Payment for the addition of extra material shall be made under Pay Item C10.10.

(iv) Material stabilisation/improvement products/additives

(a) Stabilising Agent: Nano-silane Modified (bitumen) Emulsion (NME) with or without polymer/nano-polymer combinations.

During the Detailed Design Phase of the project the Design Engineer must have tested and proved (as contained in the Detailed Design Report) the availability of modified bitumen emulsions that meets the criteria as specified as contained in the following details:

The specified cold-mix Silane-Modified (bitumen) Emulsion will consist of a **anionic SS60 bitumen emulsion** with a emulsifying agent ("soap" or surfactant) consisting of a Sodium Hydroxide basic molecule with a alkyl group consisting of a $CH_3(CH_2)_n$, carbon-chain where n > 15. (Vinsol resin or equivalent). The supplier/contractor will take full responsibility for using an emulsifying agent resulting in inferior test results and/or stability.

The specified bitumen-emulsion must be modified with a compatible (as tested with the XRD-determined mineralogy of the materials) **anionic** alkyalkoxy (organo-functional) **nano-silane** (siloxane) resulting in a stabilised mix meeting the minimum requirements as specified in Table **C1002/1 for the pavement layer during construction and Table C1002/2 during detailed material design in the laboratory**, using the prescribed test procedures as detailed in clause C1013. The nano-silane used must be environmentally stable and produce/release NO adverse negative substances during the process of hydrolysis (i.e. when mixed with the construction water). A Safety Sheet to this effect must be produced by the supplier.

The modified bitumen emulsion must have a guaranteed on-site stability exceeding 2 months and a Viscosity allowing for the in-situ cold recycling of the available materials, taking into account storage at high temperatures during summer months and possible cold temperatures during winter months. The supplier/contractor will take full responsibility for maintaining the stabilising agent on site to ensure that during storage before application the modified bitumen emulsion stabilising agent will remain stable with no visible separation and without an increase in viscosity during storage. The stabilised mix must meet the following minimum specifications proven be the supplier/contractor:

i. A guaranteed shelf-life on site (e.g. in flow bins if applicable) exceeding 2 months. (The shelf life can normally be increased to at least 6 to 9 months by through circulating the mix once a week using a normal circulation pump.)

ii. Laboratory test results using the prescribed rapid curing test procedure on available materials from site testing the UCS (dry and wet) and ITS (dry and wet) and meeting the required retained cohesion ($Its_{wet}/ITS_{dry)}$ in percentage). The average values of at least 3 tests shall be used to obtain the laboratory results. The laboratory results should meet the criteria as contained in Table C1002/1 (which is 1.6 x times the results used for quality control on site as per material design guidelines for stabilising agents used by the Gauteng Province Department of Roads and Transport).

iii. Additional test samples shall be prepared and cured at 25 - 30°C for 28 days and retested. The test results should either show similar (± 10%) or higher results as tested after the initial rapid curing process as contained in Table C1002/1 to ensure that no negative mineral and or stabilising agent interaction or degeneration of polymers (where applicable) occur.

The prepared NME on site must be ready for immediately dispersion within the construction water (using a standard circulation pump) ready for stabilisation.

It is important to note that all containers and water tankers must be thoroughly cleaned before the NME is added. Unclean (contaminated) equipment will result in the activating of any residual bituminous mix left in the container or water tanker when the NME is added, resulting in an unusable sticky substance, such as balls or strings of bitumen. Any losses occurred during construction due to the use of contaminated equipment will be to the cost of the contractor.

No cement or lime will be added.

TABLE C1002/1: STANDARD SPECIFICATIONS FOR NANO-MODIFIED EMULSION (NME) STABILISING MATERIALS (TO BE USED DURING CONSTRUCTION AS QUALITY CONTROL)

Test or Indicator	Material[1]	Material classification			
		NME1	NME2	NME3	NME4
Minimum material requirements before stabilisation and/or treatment (Natural materials)					

Material spec.(minimum) Unstabilised material: Soaked CBR (%) (Mod AASHTO)	NG /(CS)	> 45(95%) and ACV < 30% or 10% FACT >110 kN	>45 or >35 (95%) and ACV< 30% or 10% FACT >110 kN	> 25 (95%)	> 10 (93%)
Plasticity Index (PI)	CS	< 10	< 10	-	-
	NG	< 12	< 12	< 16	< 16
	GS	-	< 12	< 16	< 16
	SSSC	-	-	-	< 16
PI - 0.075 fraction (test when OMC >8% and/or % passing 0.075 mm sieve >10%)	CS	< 15	< 15	-	-
	NG	< 20	< 20	< 25	< 40
	GS	-	< 20	< 25	< 30
	SSSC	-	-	-	< 30
Grading modulus	NG	> 2.0 (G4 Grading)	> 1.5	> 1.2	> 0.45
	GS	-	>1.5	> 1.2	> 0.75
DCP DN (mm/blow) (Material compacted to spec. before stabilisation)		< 3.6	< 5.7	< 9.0	< 18.6
Material specifications after stabilisation and/or treatment					
Mod AASHTO density		> 100%	> 98%	> 97%	> 95 %
DCP DN (mm/blow) Material compacted to spec. (after stabilisation)		< 1.1	< 1.6	< 2.6	< 3.4
UCS (wet) (rapid curing method: 24h at ambient temp (30°C) + 48h at 40°C - 45°C + 24h cooling + 4h water soaking) (kPa)	150mm Φ Sample	> 2 000	> 1 200	> 700	> 450
UCS (dry) (rapid curing method: No soaking in water) (kPa)	150mm Φ Sample	> 2 500	> 1 700	> 1 000	> 750
ITS (wet) (kPa) (rapid curing as per UCS method)	150mm Φ Sample	> 140	> 100	> 80	> 60
ITS (dry) (kPa) (rapid curing as per UCS) (no soaking in water)	150mm Φ Sample	> 175	> 140	> 100	> 80
Retained Cohesion: ITS: Wet/Dry (%)	All	> 80	> 70	> 65	> 60
Typical Effective Elastic Moduli for pavement design (MPa)*		600 - 300	400 - 250	300 - 200	220 - 180

[1] CS – crushed stone; NG – natural gravel; GS – gravel soil, and SSSC – sand, silty sand, silt, clay. * These recommended values could vary considerably and are dependent of various influences including, appropriate mix design, **pavement balance**, quality control during construction, etc.

TABLE C1002/2: STANDARD SPECIFICATIONS FOR NANO-MODIFIED EMULSION (NME) STABILISING MATERIALS (TO BE MET DURING THE DESIGN STAGE IN THE LABORATORY)

Test or Indicator	Material[1]	Material classification			
		NME1	NME2	NME3	NME4
Minimum material requirements before stabilisation and/or treatment (Natural materials)					
Material spec.(minimum) Unstabilised material: Soaked CBR (%) (Mod AASHTO)	NG /(CS)	> 45(95%) and ACV < 30% or 10% FACT >110 kN	>45 or >35 (95%) and ACV< 30% or 10% FACT >110 kN	> 25 (95%)	> 10 (93%)
Plasticity Index (PI)	CS	< 10	< 10	-	-
	NG	< 12	< 12	< 16	< 16
	GS	-	< 12	< 16	< 16
	SSSC	-	-	-	< 16
PI - 0.075 fraction (test when OMC >8% and/or % passing 0.075 mm sieve >10%)	CS	< 15	< 15	-	-
	NG	< 20	< 20	< 25	< 40
	GS	-	< 20	< 25	< 30
	SSSC	-	-	-	< 30
Grading modulus	NG	> 2.0 (G4 Grading)	> 1.5	> 1.2	> 0.45
	GS	-	>1.5	> 1.2	> 0.75
DCP DN (mm/blow) (Material compacted to spec. before stabilisation)		< 3.6	< 5.7	< 9.0	< 18.6
Material specifications after stabilisation and/or treatment					
Mod AASHTO density		> 100%	> 98%	> 97%	> 95 %
DCP DN (mm/blow) Material compacted to spec. (after stabilisation)		< 1.1	< 1.6	< 2.6	< 3.4
UCS (wet) (rapid curing method: 24h at ambient temp (30°C) + 48h at 40°C - 45°C + 24h cooling + 4h water soaking) (kPa)	150mm Φ Sample	> 3 200	> 1 750	> 1100	> 750
UCS (dry) (rapid curing method: No soaking in water) (kPa)	150mm Φ Sample	> 4 000	> 2 500	> 1 600	> 1200
ITS (wet) (kPa) (rapid curing as per UCS method)	150mm Φ Sample	> 225	> 160	> 110	> 80
ITS (dry) (kPa) (rapid curing as per UCS) (no soaking in water)	150mm Φ Sample	> 280	> 225	> 160	> 130
Retained Cohesion: ITS: Wet/Dry (%)	All	> 80	> 70	> 65	> 60
Typical Effective Elastic Moduli for pavement design (MPa)*		600 - 300	400 - 250	300 - 200	220 - 180

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CS – crushed stone; NG – natural gravel; GS – gravel soil, and SSSC – sand, silty sand, silt, clay. * These recommended values could vary considerably and are dependent of various influences including, appropriate mix design, **pavement balance**, quality control during construction, etc.

(b) Additives for granular material stabilisation/treatment alternatives other than (a).

The material stabilisation/treatment additive must have a guaranteed on-site stability exceeding 2 months taking into account storage at high temperatures during summer months and possible cold temperatures during winter months. The supplier/contractor will take full responsibility for maintaining the stabilising additive/product on site to ensure that during storage before application the additive/product will remain stable with no visible separation of particles and without any change in measurable properties during storage. The stabilised mix must meet the following minimum specifications proven be the supplier/contractor:

i. A guaranteed shelf-life on site (e.g. in flow bins if applicable) exceeding 2 months. (The shelf life can normally be increased to at least 6 to 9 months by through maintaining the additive/product on a regular basis as required by the supplier.)

ii. Laboratory test results using the prescribed rapid curing test procedure on available materials from site testing the UCS (dry and wet) and ITS (dry and wet) and meeting the required retained cohesion ($Its_{wet}/ITS_{dry)}$ in percentage). The average values of at least 3 tests shall be used to obtain the laboratory results. The laboratory results should meet the criteria as contained in Table C1002/1 (which is 1.6 x times the results used for quality control on site as per material design guidelines for stabilising agents used by the Gauteng Province Department of Roads and Transport).

iii. Additional test samples shall be prepared and cured at 25 - 30°C for 28 days and retested. The test results should either show similar (± 10%) or higher results as tested after the initial rapid curing process as contained in Table C1002/1 to ensure that no negative mineral and or stabilising additive/product interaction or degeneration of the additive/product (where applicable) occurs as an indication of durability.

The prepared stabilising additive/product on site must be ready for immediately dispersion within the construction water (using a standard circulation pump) ready for stabilisation or the supplier must clearly specify the process of application during construction process to ensure that a uniform mix with uniform qualities is achieved. The differences in methods of application will be to the cost of the contractor.

It is important to note that all containers and water tankers must be thoroughly cleaned before any stabilising additive/product is added. Unclean (contaminated) equipment could result in the activating of any residual mix left in the container or water tanker when the stabilising additive/product is added, resulting in an unusable substance. Any losses occurred during construction due to the use of contaminated equipment will be to the cost of the contractor.

c) Water.

Water used for diluting the stabilising additive/product shall be potable water (clean and free from any salts and contamination) that will cause the stabilising additive/product to be adversely affected by these chemical impurities. The stabilising additive/product will tested for compatibility with the compaction water.

Water must be potable and the pH shall not exceed 7 (or as required for the use of the specific stabilising additive/product). Should local sources be considered, prior laboratory testing to ensure acceptability will be required.

The quality of the water must adhere to the specifications given in Table C2002/3. Any additional requirement for the construction water as required by the supplier of the stabilising additive/product will be to the cost of the contractor.

(v) Chemical modification of material

No additional chemical modification of the stabilised material will be allowed if not contained in the original specification. In all cases the requirements given in Table C1002/1 and C1002/2 s given in Item (iv) must be met.

(vi) Stabilisation of sub-base

In the case of the rehabilitation of an existing road or the construction of a new road, the sub-base shall conform to requirements of the layer as per design. In all cases the possible consequences and compatibility of the layer characteristics in terms of the

expected behaviour of the pavement structure as a whole needs to be assessed by the Engineer.

TABLE C1002/3: WATER CLASSIFICATION FOR CONSTRUCTION TESTING

		Water Quality Classification Code						
		H0	H1	H2	H3	H4	H5	
Property	Unit	Pure water (AR)	Clean water (Rain)	Treated water (Municipal)	Silty (muddy) water with low salt content	Highly mineralised chloride sulphate water (brackish)	Waste brack, sewage, marsh, sea, etc water	Method
PH*	-	7.0	5.7 – 7.9	4.5 – 6.5	4.5 – 8.5	9.0	-	SABS M113 SM 11 - 1990
Dissolved solids*	ppm	0	1000	1500	3000	-	-	SABS 213 SM213 - 1990
Total hardness*	-	None	None	Temporary	Temporary	Permanent	-	SABS 215 SM 215 - 1971
Suspended matter	ppm	0	2000	2000	5000	-	-	SABS 1049 SM 1049 - 1990
Electrical conductivity	mS/m	0	200	200	500	-	-	SABS 1057 SM 1057 – 1982
Sulphates (SO_4)	ppm	0	200	300	500	1000	-	SABS 212 SM 212 - 1971
Chlorides (Cl)	ppm	0	500	1000	3000	5000	-	SABS 202 SM 202 - 1983
Alkali Carbonates (CO_3) & Bicarbonates (HCO_3)	ppm	0	500	1000	1000	2000	-	SABS 241 - 999
Sugar	-	Negative	Negative	Negative	Negative	Negative	-	SABS 833
Quality of water required		Untreated layer works	✔	✔	✔	✔	Investigate the effect on the quality of the material	
		Chemically treated layer works	✔	✔	Investigate the effect on the quality of the stabilised material	Investigate the effect on the quality of the stabilised material		
		Concrete mass	✔	✔	✔	Investigate the effect on the quality of the material		
		Concrete prestressed	✔	✔	References: 1. Concrete Technology – Dr S Fulton (1989) 2. Materials Manual (PAWC)			
		Slurry & emulsion	✔	✔				
		Soil/gravel tests	✔	✔				
		Chemical or control tests	✔	✔				

C1003 COMPOSITION OF RECYCLED MIXES

During rehabilitation of existing pavement layers, the recycled material shall consist of the existing surfacing, granular material from existing pavement layers, additional material where required and an applicable stabilising agent/product. The actual composition of the mix shall be determined by the Engineer in order to comply with the testing requirements as specified in Table C2001/1 for quality control purposes and Table C2001/2 during the detailed design phase in the laboratory.

Adjustments to the actual mix constituents may be required during construction (taking into account the effect of construction procedure (e.g. conventional equipment vs recycler vs central mixing plant) and climatic conditions and shall be authorised by the Engineer. The Engineer reserves the right to adjust the composition of the mix at any time should he deem it necessary. The Contractor and supplier shall provide to the Engineer the proposed final mix proportions based on the required test results and the Engineer must approve the results before any materials are ordered. The risk of alternative designs using any alternative additive/product not specified remains with the contractor as per documents applicable to the contract.

The average values for maximum dry densities shall be confirmed by the Engineer prior to any work commencing.

C1004 PLANT AND EQUIPMENT

THE SPECIFIED STABILISING AGENT COULD BE HIGHLY REACTIVE AND IT IS IMPERATIVE THAT ALL STORAGE TANKS, WATER TANKS, ETC., BE THOROUGHLY CLEANED WITH NO RESIDUE FROM PREVIOUS MIXES PRESENT IN THESE TANKS. THE CONTRACTOR WILL ALLOW THE ENGINEER TO INSPECT THE EQUIPMENT BEFORE USE TO ENSURE THAT THE EQUIPMENT IS SUITABLE FOR USE WITH THE SPECIFIED NME STABILISING AGENT OR ANY OTHER ALTERNATIVE AS RECOMMENDED BY THE CONTRACTOR AND HIS SUPPLIER. IN ALL CASES THE SUPPLIER WILL ENSURE THAT THE STABILISING AGENT APPLICATION IS CLEARY SPECIFIED AND THE CONTRACTOR WILL TAKE FULL RESPONSIBILITIES TO MEET THE SPECIFICATIONS OF THE SUPPLIER THAT MUST BE FREELY AVAILABLE FOR QUALITY CONTROL PURPOSES.

(a) Conventional Plant

A heavy duty motor grader is an essential item of plant for NME stabilisation, irrespective of the combination of any of the other plant items used. This grader is required to pre-shape the material prior to being treated, for processing the material and, thereafter, to cut the layer to final levels. Processing by grader includes mixing the material prior to treatment and mixing in the additive and the diluted NME oe alternative additive/product.

A milling machine will be required to break up a thick asphalt layer and/or high strength cemented material to produce a material suitable for the stabilisation or treatment. When in-situ material is to be augmented with imported material, a milling machine can also be effectively used to blend the two materials after the additional material has been levelled out on top of the in-situ material and pre-shaped with a grader.

Alternatively, layers that have developed high in-situ strength can be broken down using a “woodpecker-type” fitted to an excavator. The resulting chunks of pavement material can then be transported to a single-stage crusher to be crushed and transported back to the road for further processing.

(b) Recycling Equipment

The plant shall be so equipped that it will be able to recycle pavement layers to depths up to at least 300 mm in one operation. The plant shall be equipped so that the stabilising agent mixed in with the construction water as per calculations can be added uniformly in a calibrated and controlled manner directly to the material being recycled. Width reduction must be possible on the application nozzles when overlap recycling is done. The recycling depth shall be controlled electronically.

Pre-milling of the layer(s) to be stabilised with the surfacing (when specified) will be done to ensure that a uniformly mixed layer is present before stabilisation with the recycler is to be done.

The direction and speed of the recycling machine and the speed of rotation of the scarifying drum shall be adjusted so as to obtain the required grading and sufficient mixing of all the components of the recycled material. The machine shall be capable of making a neat vertical cut at the outer edges when recycling the layer.

The recycler should, as a minimum, be equipped with:

- Self-cleansing nozzles, and
- Be equipped with a micro-computer able to adjust the application of the stabilising agent adjusted to the speed of the recycler – the proper working of this equipment is essential to ensure that and mix be applied to specification.

The recycler will be pre-tested using clean water to ensure that all systems as per specification are in proper working order and that the stabilising agent will be added as adjusted by the speed of the recycler.

(c) Water Tanker

Self-propelled water tankers, with a 15 000 litre capacity, are essential plant items for the successful construction of a stabilised layer. In addition to supplying the stabilising agent/additive/product for mixing, water tankers are required to ensure proper finishing of the treated layer of material after the initial mixing and processing
stage has been completed (AT NO STAGE SHOULD WATER WITHOUT THE STABILISING AGENT BE ADDED TO THE LAYER).

Sufficient construction water mixed with the stabilising agent must be added to the mix to account for loss of moisture during processing, taking into account the equipment to be used and climatic conditions to ensure that compaction starts with the layer preferably at approximately OMC. (Results from detailed testing under actual as well as research conditions indicate that the OMC of the material is reduced by approximately 10% and that the moisture/density relationship may not be as critical as that of stabilisation without nano-silane modifications.) Sufficient water tankers must be provided to ensure that the processing of the material is a continuous procedure with no stopping to wait for a tanker.

Where applicable, water tankers involved with the treatment and distribution of a stabilising agent should be earmarked only for the transportation of the stabilising agent in various stages of dilution as dictated. In the case of NME stabilisation, it is recommended that a small percentage of the NME mixture be retained in the tanker in the cases of the use of conventional equipment to treat a “dry” surface before or during compaction when the moisture loss is deemed to be excessive for one or another reason that may occur in practice due to numerous unforeseen circumstances.

A surface is visually considered to be to dry when fine cracks appear directly behind the rollers.

All water tankers used for NME treatment must be equipped with a circulating pump system to circulate the diluted NME after standing for an extended period and for circulating during the dilution process. Water tankers must not be fitted with a conventional spray-bar but with valves (such as a clam-lock valve) which will not easily clog. The application of the diluted NME is a cold process and the addition of the nano-silane agent reduces the possibility of blockages of the nozzles considerably. However, it is the responsibility of the contractor to ensure that no such blockages occur, resulting in the uneven distribution of the stabilising agent. In cases where such blockages do occur the Engineer may require the layer to be remixed using conventional equipment. Tankers must be properly flushed should they need to stand empty for extended periods (e.g. overnight).

(d) Rollers

The equipment to be used for the conventional breaking-up and excavation of existing pavement layers will be determined by the size and depth of the pavement section to be processed or excavated, taking into consideration the fact that work may have to be carried out in restricted areas.

One heavy duty grid roller and an adequately powered pneumatic tyre tractor which will pull the grid roller when fully loaded, or an equivalent self-propelled sheep foot roller, may be required in the case of very course material.

The compaction of a a stabilised base layer is normally achieved with a vibratory smooth drum roller in combination with a pneumatic wheel roller to achieve a surfacing finishing, meeting a strict specification.

(e) General

Static tanks should be provided to store sufficient quantities of the stabilising agent for the needs of the project. Normally such tanks will have a capacity of between 30 000 and 120 000 litres. Static tanks must be fitted with a circulating pump system which will enable the stored stabilising agent to be properly circulated from time to time in the static tank, especially if the stabilising agent has been standing for a period of 2 to

3 consecutive days. These tanks must be fitted with a flowmeter to ensure that the required percentage of the stabilising agent be added to the construction water.

C1005 SETTING-OUT AND CONTROL OF THE WORK

The Contractor shall establish his own reference and level beacons for the settingout and control of the works.

The Contractor shall indicate his own reference and control beacons to the Engineer at least one week before the work is programmed to commence. The Engineer will take control measurements to determine the accuracy and adequacy of the reference/control beacons, and may instruct the Contractor to correct any faulty work and to take and provide such additional measurements and details as may be deemed necessary by him. This survey work will not be measured and paid for directly and compensation for any work involved in staking or setting out will be deemed to be covered by the rates tendered and paid for the various items of work included in this contract.

No payment will be made for any inconvenience or delay caused by compliance with these requirements.

C1006 CONSTRUCTION

(a) Removal of grass and weeds

Prior to commencing in-situ recycling, all grass, weeds, etc., encroaching into or onto the road surface or growing between the edge of the existing surfacing and kerbs, channels, etc., shall be removed.

(b) Preparing the pavement surface

Before cold in-situ recycling may commence, the pavement surface shall be clean and free from deleterious material.

For the conventional method any asphaltic surface with granular sub-layers and/or cemented-layers will be pre-milled prior to the preparation of the layer.

Extra material shall be spread to the thickness and width as specified. The area to be recycled shall be properly demarcated. No payment will be made for cold, in-situ recycling beyond the required width.

Before cold in-situ recycling may commence, the moisture content of the granular material shall be determined in an approved manner so as to determine the amount of water required to reach optimum moisture content. In the case of the measured moisture content exceeding optimum by more than 0.5% with the addition of the diluted stabilising agent, the layer shall be ripped and left to dry until the moisture content has reached an acceptable level by applying the stabilising agent and reaching the required moisture conditions..

(c) Construction in confined areas

In such an event where any rehabilitation or reconstruction work as specified in this section has to be executed in an area where the width of which is less than 1.0 m or the length of which is less than 50 m and the area is less than 50 m^2,it shall be classified as work in restricted areas.

(d) Recovery of bituminous material

If so required by the design, existing bituminous material shall be milled out as indicated on the drawings. The recovery material shall be transported and stockpiled as specified in Section 3800.

The limits of milling shall be demarcated clearly and these limits shall not be exceeded by more than 100 mm. Areas milled outside the specified limits shall be repaired by the Contractor at his own cost and to the satisfaction of the Engineer.

(e) Spreading of extra material on a layer prior to recycling

Where the existing pavement layer or surfacing level is too low or existing material has to be spoiled due to unsuitability and where specified or instructed by the Engineer, suitable pavement material shall be added to the layer to make up the shortfall prior to the recycling the layer. Suitable pavement material for addition to make up a layer shortfall shall consist of naturally available materials as specified or directed by the Engineer.

The extra pavement material including reclaimed asphalt (RA) shall be spread uniformly over the full area of the underlying shortfall layer by means of an approved type of mechanical spreader to such thickness as to comply with the requirements specified in Clause C1010 after the final compaction. Segregation of the materials

shall be avoided and the additional material shall be placed free from pockets of coarse and fine materials. Extra material shall only be spread on the section to be recycled and only immediately prior to the recycling operation.

(f) Application of stabilising agent diluted with water

At no time whatsoever should an undiluted stabilising agent (such as NME) be applied to the layer of material that is being processed. The NME must be added to the construction water (taking into account the total fluid content of the NME (the nano-modified stabilising agent effectively reduces the OMC of the material) hence not only the 40% water within the bitumen emulsion need to be taken into account but the total fluid content) to ensure that the mix is properly distributed throughout the layer. The supplied NME need to be diluted by a factor of between 1:4 (1 part NME and three parts water) and 1:1 (50-50) to ensure proper distribution of the stabilising agent. High percentage of fine material (percentage passing the 2 mm sieve will require higher rates of dilution.

Coating of all the granular particles within the layer will not take place when the NME is added separately to the construction water as is possible with modern recycling equipment. As a consequence, the in-situ moisture content of the untreated layer must never be so high that it cannot accommodate the NME that has been diluted with the construction water.

(g) Pre-treating of the exposed base layer

An appropriately designed NME stabilising agent will not require the pre-treatment of materials to account for “problem” minerals such as Smectites, Muscovite, etc, The Nano-technology automatically addresses the presence of such minerals during the detailed design phase and is specifically designed to neutralise the effect of these minerals. In cases with high contents of specifically identified minerals a pretreatment may be prescribed using an appropriate Nano-product prior to the stabilisation process. The identification of the need for pre-treatment shall be done as part of the detailed design process through the detailed testing of the mineral composition of available materials (using XRD-scans) to be used in the construction/rehabilitation of a road pavement.

(h) Breaking down of material using conventional methods

During rehabilitation works, the existing pavement material shall be broken down to the specified depth and processed in place.

The ripped material shall then be broken down in-situ with a fully loaded grid roller hauled by an adequately powered tractor. During the process of grid rolling and breaking the material, the material shall be windrowed constantly and any oversize material shall be removed.

Unsuitable material for sub-base and base shall, as directed by the Engineer, be removed and spoiled and will be paid under pay Item 10.13.

Where sub-base layers need to be constructed, the base material shall be windrowed to the side and the sub-base layer should be inspected first. After inspection by the Engineer the demarcated sub-base area should be reworked and re-stabilised if so required by the Engineer.

(i) Adding diluted NME

The emulsion tanker supplying the diluted NME (containing the mix of the NME and the required construction water as measured and calculated) shall be equipped with an approved measuring device (dipstick) to enable the site staff to take control dips at intervals specified by the Engineer. The recycling operation will be cancelled/interrupted unless this requirement is met.

The method of introducing the various materials comprising the final mix shall be subject to the Engineer's approval. Care shall be taken to prevent excessive loss of moisture between the time when the materials are mixed and when they are compacted on the road.

(j) Spreading

The recycled mix shall be spread and levelled with a motor grader to the required width and to such thickness as to comply with the requirements specified in Clause C1010 after final compaction. Segregation of the materials shall be avoided and the layers shall be free of pockets of coarse or fine materials.

(i) Mixing Recycler

The recycled base material, extra material, NME diluted in the construction water, shall be thoroughly mixed by the recycling mixing process with plant as specified in Clause C1004.

The NME diluted in the construction water, shall be measured by mass and quantities, calculated in accordance with the formulas given in Clause C1003, and shall be introduced continuously in a controlled manner which is proportional to the rate of advance to ensure that the correct quantity of each material is added to the full width of the section being recycled.

(ii) Conventional Method

Blade-mixing by grader is undertaken by using the blade to move the material from side to side. This mixing process is often supplemented with the use of ploughs and/or rotavators. Where the width of the treatment restricts the horisontal movement of the material, extra use should also be made of the grader rippers with specially designed “shoes” welded onto the rippers. Such shoes are in the shape of a horizontal “V”, with the sharp end of the V pointing in the direction of travel of the grader. The rippers with their V-shaped shoes are lowered to the treated depth and the “fast forward” gear of the grader is used to plough through the layer. In this manner, the material is pushed aside, ensuring that proper mixing is achieved, even when working in confined widths.

NME must first be diluted with the compaction water to a residual NME content of between a 1:2 to 1:4 dilution and applied in several applications onto the material. Water tankers are used to apply the NME and the grader(s) must travel directly behind the water tanker, immediately covering the freshly sprayed NME with material, thereby preventing excessive loss of moisture and the NME from breaking. The volume of diluted NME applied is determined by the residual or NME required, expressed as a percentage by mass of the finally treated layer.

Should weather conditions be particularly hot or dry, then the NME must be diluted with proportionately more water having to be added to the NME.

Care should be taken to ensure that the diluted NME is applied in such a way that no rivulets are formed and that the NME does not run off the layer before it has been mixed in.

During mixing, attention must be paid to the fluid content of the mix. The fluid content is the total quantity of fluid in the mix, including hygroscopic moisture, the diluted NME still in suspension and the water in the NME.

The fluid content should not be so high as to result in deformation of the surface under final compaction. The optimum fluid content determined in the laboratory may be amended, based on on-site observations, to make allowance for the type of compaction equipment being used.

When working with porous material, no dry material should be present at the time of mixing in the NME, since the water absorption of the aggregate may lead to the premature breaking of the NME.

Where the existing asphalt surfacing or cement base layer is being recycled with the underlying gravel layer using conventional construction equipment, the asphalt layer must first be milled off and left in windrow on top of the granular base that is to be recycled. Once the asphalt layer has been milled off in this manner then the base layer can be milled or ripped and broken down. Once the milled asphalt layer and the existing gravel base material have been thoroughly blended, then the additive must be mixed in immediately ahead of the introduction of the diluted NME on the same day.

(k) NME Preparation of treated additive

The following will need to be determined in advance for input into the Moisture Calculation Sheet: Length, width and depth of section to be stabilised; MOD, OMC and in-situ moisture content; Content of water tanker in litres; Water tanker volume will also need to be calibrated and marked out on a volume measuring gauge.

- Prior to applying any NME to the road, the additive shall be mixed with water in the water tanker to form the diluted NME which, when applied to the soil, will act as a carrier of the diluted NME to the soil fines.
- The Contractor shall determine the rate of dilution of the additive by means of the Moisture Calculation Sheet, which may range from 1 litre of NME to between (5 litres and 40 litres) of water depending on the type of soil, in-situ moisture content and amount of soil treatment required. This calculation sheet shall be submitted to the Engineer on a daily basis for approval both before and after completion of each section to be stabilised. NME stabilised soil will only reach maximum

strength once a compacted moisture content of OMC is reached (taking into consideration that the nano-silane modification will normally reduce the OMC by about 10%). In order to reach this target OMC, it may be necessary

to apply 1,0% to 3,0% moisture above OMC (depending on climatic conditions which could result in the drying and loss of moisture due to evaporation during very hot conditions) and the mixing equipment used – conventional grader mixing will take longer and will allow more moisture to escape (evaporate) than mixing with a recycler. Compaction at moisture conditions which are too low will lead to the formation of fine cracks (immediately visible after the roller),which will compromise the integrity of the top of the layer, resulting in the formation of a weak inter-layer at the top which may result in the failure of the seal by separation with the rest of the base-layer (the appearance of fine “cracking” when compaction commence is normally an indication of a too low a moisture content and a further application of some diluted NME (kept in reserve in the water-tanker) may be needed to increase the surface moisture to achieve the desired compaction densities and a uniform layer. Too high moisture conditions will be seen when the layer is moving in front of the roller (kneeing) – in these cases, drying out of the layer may be required by ripping and re-compaction (as per previous discussions and guidelines).

- The diluted NME may be sprayed onto the road surface by means of a spray bar fitted to the water tanker or by hand spraying in places with difficult access.
- Initial thorough and complete mixing of the NME with water is essential. Preferably an electrical or petrol driven stirrer must be used. Generally circulating the tank contents using the on board pump provides **inadequate** mixing unless:
    1. The pump is of sufficient capacity to circulate the entire contents of the tank in 15 minutes; and
    2. There is no internal baffles in the tank restricting circulation; and
    3. Prior to commencement of spraying, the contents are circulated for at least 20 minutes.

(l) Compaction

The completed compacted layer shall have a minimum in-situ dry density as specified for the specific layer (as per requirement of the designed layer as per Table C1002/1).

It shall be the responsibility of the Contractor to determine the maximum dry density and Optimum Moisture Content (OMC) of the material to be stabilised for purposes of quality control (compaction control). The Contractor may select any suitable compaction technique to achieve this required compaction, subject to the following conditions:

The initial compaction shall be carried out with plant, which achieves stability suitable for subsequent compaction without causing undue displacement of the material or deformation of the layers. The rolling pattern shall be designed so as to retain the shape of the layers as far as possible.

The types and number of compaction equipment to be used and the amount of rolling to be done shall be such as to ensure that specified densities are obtained without damage being done to lower layers or structures. During compaction the layer shall be maintained to the required shape and cross-section, and all holes, ruts and laminations shall be removed.

Compaction equipment shall be adequate for obtaining the specified density within the specified time limits.

The compaction equipment and techniques shall be capable of producing the specified surface finish and density without any interruption.

Not more than two (2) hours shall elapse between the time of starting the mixing process and that of starting to compact the material.

From the time when the diluted NME is added and mixed, not more than four (4) hours shall elapse until the compaction has been finally completed.

It is important to note that when adding water to material **only diluted NME should be used**.

The only time when the water can be used on its own is during the **pre-wetting (recommended!) of the completed layer prior to priming.**

At no time would it be allowed to "cutting back" materials to achieve levels without remixing of the layer – materials added by "cutting back" material will result in "biscuit" layers and the disintegration (breaking up) of the top of the layer. Under such circumstances high penetration of the stone with associated

bleeding within the wheel tracks will occur when a surfacing consisting of a seal is used. A ring and ball test performed on top of the base-course prior to sealing should normally expose this weakness and potential risks.

(m) Rejected work

The Contractor shall note that should he fail to meet the specified requirements for the cold NME stabilised layer, he shall remove the unacceptable layer and replace it with approved material all at his own expense or as instructed by the Engineer.

Reworking of an existing layer may be allowed by the Engineer by ripping of the stabilised layer, adding 50% of the original NME stabilising agent and compaction at the required OMC as per original process to achieve the required results. Such reworking of the layer will be at the risk of the contractor.

(n) Providing a temporary wearing course

Immediately after completion of the compaction described in subsection (l), diluted NME shall be applied to the finished surface using a water truck and shall be rolled and slushed by means of steel-wheeled rollers with a mass of not less than 12 tons each, and/or with pneumatic rollers.

The following process is to be followed:

1. Immediately after compaction, slushing of the surface will commence: Spray 1 litre/m² of the diluted NME onto the surface followed immediately with further compaction by means of a 13 ton vibratory roller which must follow directly behind the water cart. A 22 ton pneumatic tyre roller (PTR) must then follow directly behind the vibratory roller.
2. Turn around and on the same strip have the water cart first drenching the surface with a further 1 litre/m² diluted NME. This time the pneumatic tyre roller follows directly behind the water cart and the vibratory roller follows closely behind the PTR. It is important that the water cart and roller must work in close tandem at all times; in order to prevent any pick up of the material onto the drum of the vibratory roller (although unusual with nano-modified emulsion) .
3. Continue points 1 and 2 until the total area to be worked is completed.
4. The area treated then is to be kept closed to traffic in order for it to properly set (until the top 25mm of the layer has dried out). The time of required closure is

dependent on the prevailing weather. Due to the addition of the Nano-silane product water is forced from the layer and it normally dries much quicker than traditional emulsion stabilisation of layers which depends only on evaporation as a method of drying. In very dry and hot conditions the layer can sufficiently

dry within a period of less than 24 hours. The final surface should be smooth, tightly knit and free of undulations, corrugations, holes, bumps or loose material.'

The application of an applicable compatible prime (i.e. a compatible nano-silane based prime) when the base has reached a moisture content of 50% of OMC should prevent most damage under conditions of light trafficking in urban areas. P**r**e-wetting of the completed layer prior to priming is recommended.

(o) Disposal of surplus material

Recovered pavement material remains the property of the Employer.

Surplus materials, including waste or over-size material, bladed or skimmed off the road, shall be stockpiled at designated areas within a free-haul radius of 5km as directed by the Engineer.

Should the Employer decide not to use the surplus material, the Contractor shall then dispose of the material.

(p) Checking moisture content prior to surfacing

The mixing and placing of asphalt or seal will not be allowed if:

(i) free water is present on the working surface; or

(ii) the moisture content of the upper 50 mm of the recycled base exceeds 50% of the Optimum Moisture Content (OMC).

C1007 WEATHER LIMITATIONS

No in-situ recycling shall be commenced if the threat of rain is present.

C1008 OPERATIONAL LIMITATIONS

The Contractor shall arrange his in-situ recycling of existing pavement layer operations in such a manner as to minimise the disruption of public traffic. Every effort shall be

made to ensure the safety of the travelling public on existing roads through the site of the works at all times. In-situ recycling operations shall be carefully planned and executed in accordance with the following limitations:

(a) Individual work areas shall be clearly demarcated with traffic signs, delineators and traffic control facilities as specified.

(b) The individual work areas shall be planned in such a manner that all recycled pavement layers are compacted as specified in Clause C1006 (l) for a day's production.

(c) No priming shall be done unless the recycled layers have been inspected and accepted by the Engineer.

(d) Within individual working areas, the Contractor shall make adequate provision for drainage of milled, excavated and/or asphalt overlay areas where water can pond or be contained against a difference in depth on the roadway. No separate payment will be made for the provision and use of standby pumps and dewatering equipment of cutting of drainage slots and/or channels to effectively drain the roadway surface where instructed by the Engineer in the interests of safety for the travelling public. The Contractor shall make due allowance for this drainage in this tendered rates.

(e) Delineators shall be placed along each longitudinal step exceeding 30mm between adjacent lanes of the roadway.

The maximum allowable step within a lane open to traffic shall be restricted to 40 mm. If, due to plant breakdown or other unforeseen circumstances, a longitudinal or transverse step higher than 20 mm occurs within a lane, the strip shall be feathered off by means of compacted asphalt over a distance of 500 mm.

(f) If rain falls during the application process, application must be stopped, the area must be stopped, the area must be sealed by means of a single roller pass and application of treated water shall only recommence once the moisture content of the area has returned to the level it was at before it started raining.

C1009 PROTECTION AND MAINTENANCE

The Contractor shall protect the completed base layer from all damage until the asphalt or seal work is complete. Any damage occurring to the completed base or any defects which may develop due to faulty workmanship, shall be made good by the Contractor at his own expense and to the satisfaction of the Engineer.

Repairs shall be made in a manner approved by the Engineer to ensure an even and uniform surface.

During working and construction of the base layer, precautionary measures shall be taken to prevent kerbs and channelling and concrete work from being damaged or shifted. Care shall be taken to protect all precast units from chipping and breakage. Concrete kerbing and channelling, as well as other structures adjacent to the road, shall be protected against staining, by NME product. Any work stained by NME shall be broken down and replaced, unless all such NME is completely removed so as not to show any stains. Painting over stained work will not be allowed.

Where the cold in-situ recycling process is to be carried out at existing structures, care shall be exercised to avoid damage to concrete elements, expansion joints, manholes, catch pits, etc. Damage caused to any element forming part of the permanent works shall be repaired at the Contractor's cost.

Damaged caused by the Contractor shall through careless operations will be repaired at his own costs. New construction shall be done in accordance with the drawings and the Specifications. The Contractor will be held responsible for the timely adjustment of all covers and frames in advance of surrounding construction, whether they are indicated on the drawings or by the Engineer or not. No claims for delays arising from the failure of the Contractor to effect the necessary adjustments in good time will be allowed.

C1010 CONSTRUCTION TOLERANCES AND FINISH REQUIREMENTS

(a) Construction tolerances

The applicable construction tolerances are the relevant tolerances indicated in Clause 3405. Where the existing granular base abuts kerbs or channels or NewJersey barriers, the new work shall extend to the edge of these facilities.

Unless otherwise specified, the recycled base shall be constructed to the existing levels, cross-section profile and cross-fall to allow for a surfacing layer.

(b) Nano-Modified (bitumen) Emulsion (NME) stabilising agents

The average rate of application of the diluted NME as measured at operating temperature in the recycling plant and water tanker shall be within 5% of the specified rate of application.

(c) Uniformity of mix (chemical stabilisation)

No chemical stabilisation agent is required with NME.

(d) Statistical judgement schemes

Routine inspections and tests will be carried out by the Engineer to determine the quality of the materials and workmanship for compliance with the requirements of this section.

The statistical judgement schemes to be used to determine whether the requirements specified are being complied with shall be those set out in Section 8300 (Scheme 2).

C1011 TRIAL SECTIONS

Where ordered by the Engineer, the Contractor shall execute trial cold in-situ recycling on the various materials to be reprocessed.

Trial sections shall be carried out at locations indicated by the Engineer.

C1012 WORK OUTSIDE NORMAL WORKING HOURS

Any work carried out outside normal working hours must be approved by the Engineer, and the Contractor shall give the Engineer at least 48 hours' notice of his intention to do work outside the normal working hours. The closure of traffic lanes will only be permitted during these times. The provision and layout of lighting for the works and warning lights for the accommodation of traffic shall be approved by the Engineer. No additional payment will be made for the provision of warning lights for work outside

normal working hours. The Contractor shall allow for the provision, erection and maintenance of additional items required in his tendered rates.

C1013 TESTING

(a) Testing

The Contractor shall give the Engineer at least 24 hours' notice of his intention to stabilise/recycle/ework, so that the actual process can be monitored and tested by the Engineer. Unless otherwise agreed in advance the Contractor shall only stabilise/recycle/rework when the Engineer or his representative is present.

(b) Test Methods for determining UCS and ITS values

The following test methods shall be used to determine the UCS and ITS values.

- To determine the maximum dry density TMH 1 method A7 or SANS 3001 GR30
- To determine the unconfined compression strength (UCS) TMH 1 method A16T or SANS 3001 GR54
- To determine the indirect tensile strength (ITS) TMH 1 method A16T or SANS 3001- GR54.

In all the above test methods the +37.5 mm material must be screened off and discarded. The aggregate passing the 37.5 mm sieve and retain on the 19.0 mm sieve must not be crushed and must be used in the testing process. A ph test must be performed to determine the acidity/alkalinity levels of the material.

The curing and testing process of the 150 mm diameter samples (127 mm high) shall be as follows:

No cement or lime added to the material

1. The prepared 150mm diameter samples as per TMH (Method A14) with no plastic covering. (Plastic covering is required when cement is included in the mix to assist in the hydration of the cement). Samples are cured for 24 hours in sunlight (or cured for 24 hours in an oven at 30°C) before being subjected to a "rapid curing"

process in an oven (for 48 hours at 40 - 45°C) (temperatures in the oven should NOT exceed 50°C).

2. After 48 hours the briquettes must be removed from the oven and allowed to cool off for twenty four (24) hours. This is preferably to be done in sunlight (or 24 hours at 30°C in oven).

3. Two (2) briquettes must be crushed to determine the ITS and UCS values. The values obtained are called the DRY ITS and the DRY UCS values.

4. Two (2) briquettes must be placed in a bath of water with a temperature of 22°C - 25°C for four (4) hours and thereafter removed from the bath and allowed to drain off excess water before determining the ITS and UCS values. The values obtained are called the WET ITS and the WET UCS values.

5. If so approved by the Engineer the “wet” tests (UCS and ITS) may suffice during the quality control during construction.

6. During the design stage 4 briquettes must be preserved outside the moulds for a period of 28 days. After 28 days the UCS (wet and dry) as well as the ITS (wet and dry) should be tested as per procedure described above. The results of the 28 day tests should not show a decrease in the values of the respective UCS and ITS tests as compared to that obtained after the rapid curing process.

C1014 TREATMENT OF GRAVEL ROADS TO PROTECT THE GRAVEL LAYER AND REDUCE DUST

All preparations of the NME materials and construction processes and testing as per normal construction and rehabilitation of roads as discussed under items C1001 to C1013 also apply to the treatment of the top layer of the gravel roads. In the case of gravel roads Table C1002/1 is replaced by Table C1014/1.

Additional protection of the surface can be provided by the application of a clear seal (similar to a traditional fog spray). The clear seal is applied as per product specifications using a diluted compatible nano-silane with the addition of a compatible polymer that will provide a protective layer similar to a traditional prime.

Table C1014/1: Recommended material specifications for the wearing courses of gravel roads treated/stabilised with Nano-modified Emulsions (NME) or similar

Test or Indicator	Material[1]	Material classification
		NME-EG4
Minimum Material Requirements Before Treatment/Stabilisation (Gravel wearing course)		
Material Spec.(minimum) – Wearing course for gravel roads: Soaked CBR (% Mod AASHTO)(Refer draft TRH20, 1990)	NG/(CS)	> 15 (95%)
Plasticity Index (PI)	CS	Not required
	NG	< 16
	GS	< 16
	SSSC	< 16
PI - 0.075 fraction (test when OMC > 8% and/or % passing 0.075 mm sieve >10%)	CS	Not required
	NG	< 40
	GS	< 30
	SSSC	< 30
Grading Modulus	NG	> 0.45
	GS	> 0.75
DCP DN (mm/blow) (Material compacted to spec. before treatment)		< 13.5
Material Specifications after Treatment/Stabilisation of the Gravel wearing course		
Mod AASHTO Density		> 95 %
DCP DN (mm / blow) Material Compaction to Spec. (After Stabilisation)		< 3.4
UCS (Wet) (Rapid Curing Method: 24h at ambient temp (30°C) + 48h at 40°C - 45°C + 24h cooling + 4h water soaking) (kPa)	150mm Φ Sample	>450
UCS (dry) (rapid curing method: No soaking in water) (kPa)	150mm Φ Sample	>750
ITS* (Wet) (kPa) (rapid curing as per UCS method)	150mm Φ Sample	> 60
ITS (Dry) (kPa) (rapid curing as per UCS)(no soaking in water)*	150mm Φ Sample	> 80
Retained Cohesion: ITS: Wet / Dry (%)	All	> 60

[1] CS – crushed stone; NG – natural gravel; GS – gravel soil, and SSSC – sand, silty sand, silt, clay.

C1014 MEASUREMENT AND PAYMENT

Item **Unit**

C10.01 **(a) Establishment of cold in-situ recycling**

Equipment/plant on site ..... lump sum

(b)

Establishment of Conventional equipment on site ..... lump sum

The tendered lump sum shall include full compensation for the provision of any number of recycling machine(s)/plant on the section of the site and the subsequent removal thereof, including additional plant required for carrying out cold in-situ recycling operations.

The lump sum will become payable after the cold in-situ recycling work has been completed and the equipment has been removed from the site.

Payment will not distinguish between the number of recycling machines or conventional units of equipment brought onto and/or removed from the site. No payment will be made for the replacement of defective plant.

Item **Unit**

C10.02 **Cold in-situ recycled granular layer treated)**

(a) Using a recycler

(i) Base layer (depth to be specified) compacted to the specified density (Table C1002/1) using a Nano- modified (bitumen) Emulsion (NME)……..cubic metre (m^3)

(ii) Sub-base (depth to be specified) compacted to design specification as per Table C1002/1) using a Nano-
Modified (bitumen) Emulsion (NME) ……..…cubic metre (m^3)

(b) Using conventional plant

(i) Base layer (depth to be specified) compacted to the required density as per table C1002/1) using a NanoModified (bitumen) Emulsion (NME)…..……..cubic metre (m^3)

(ii) Sub base (depth to be specified) compacted to the specified density as per Table C1002/1) using a Nano-

Modified (bitumen) Emulsion (NME) ……..…cubic metre (m^3)

The unit of measurement shall be the cubic metre of pavement recycled to provide the recycled base and or sub-base layer as specified.

The rate tendered shall include full compensation for the provision of all plant, labour, materials and all other incidentals necessary to produce the finished layer as specified but excluding the provision of the Nano-Modified (bitumen) Emulsion (NME) which shall be measured and paid for under item C10.03. The (bitumen) Emulsion will consist of a SS60 anionic emulsion with a emulsifying agent ("soap" or surfactant) consisting of Sodium Hydroxide with a alkyl group $CH_3(CH_2)_n$ (where n>12) (Vinsol resin or equivalent – contractor will take responsibility for using an emulsifying agent resulting in inferior test results).

The tendered rate shall also include full compensation for the milling of existing pavement layers, blending of the materials in the nominal mix ratios specified, supply, diluting nanosilane modified (bitumen) emulsion in potable water and mixing of the diluted nano-silane modified (bitumen) emulsion, spreading and final blading of the recycled mix, compacting the material to the specified density and protecting and maintaining the work in accordance with the specifications.

The tendered rate shall also include full compensation for the cleaning of the surface and the referencing of lane and control survey markings as specified.

Where ordered by the Engineer for the recycling of pavement layers to depths other than specified, the payment will be made on a *pro rata* basis between the tendered rates for nominal depths scheduled.

All failures due to the use of contaminated equipment (not thoroughly cleaned) will be for the cost of the contractor.

Item **Unit**

C10.03 NANO-MODIFIED (BITUMEN) EMULSION (NME)…….Litre (ℓ)

The unit of measurement shall be the litre of Nano-Modified (bitumen) Emulsion (NME) applied as specified or as instructed by the Engineer.

The tendered rate shall include full compensation for providing, diluting, expansion and applying the stabilising agent, irrespective of the prescribed rate of application. The Emulsion specified will consist of a SS60 anionic Emulsion using a Sodium Hydroxide emulsifier (Vinson resin or equivalent – contractor will take responsibility for using an emulsifying agent resulting in inferior test results) emulsifier. The compatible anionic nanosilane will be pre-mixed with the specified emulsion in a central plant to achieve maximum dilution of the emulsion with the nano-silane to produce a stable mix in the carrier fluid for direct application to the construction water.

Item **Unit**

C10.04 Chemical additive

No chemical additives will be required with a NME stabilising agent.

Item **Unit**

C10.05 Pre-treating the base layer with a Nano-product

No pre-treatment of lime, etc. will be required with a NME stabilising agent. Some minerals may require pre-treatment with an appropriate Nano-product Payment to be similar to Items C10.02 and 10.03.

Item Unit C10.06 Blading of surplus material to windrow……..…….cubic metre (m^3)

The unit of measurement shall be the cubic metre of surplus material bladed to windrow as specified by the Engineer.

The tendered rate shall include full compensation for all labour equipment and any other incidentals required for blading to windrow of surplus material with a motor grader.

Item **Unit**

C10.07 Removal from site of surplus material……..…….cubic metre (m^3)

The unit of measurement shall be the cubic metre of surplus material removed.

The volume shall be determined as prescribed by the Engineer and shall be the loose volume in stockpiles or its equivalent measured in hauling vehicles. Accurate load and haul sheets shall be kept on site and submitted to the Engineer. The tendered rate shall include full compensation for loading and transporting the surplus material to a designated spoil or stockpile site within a 5 km radius.

Item **Unit**

C10.08 Construction of temporary wearing course……..…square metre (m^2)

The unit of measurement shall be the square metre of recycled granular base slushed in accordance with the requirements of section C1006 (n) of the Project Specification and the tendered rate shall include full compensation therefore.

Item **Unit**

C10.09 Trial sections were ordered (extra over item C10.02 and C10.03)……..……..……square metre (m^2)

The unit of measurement shall be the square metre of recycled pavement layers as ordered.

The tendered rate shall include full compensation for the construction of the trial section of recycled pavement layers complete as specified.

Item **Unit**

C10.10 Extra over Item C10.02 for adding extra material to the layer

(a) Gravel Base (G2)…….cubic metre (m^3)

(b) Gravel sub base (G5)……..…cubic metre (m^3)

(c) RA……..……...……..…cubic metre (m^3)

The unit of measurement shall be the cubic metre of material added on the instruction of the Engineer, which quantity shall be taken as 70% of the loose volume measured in trucks, unless instructed by the Engineer that the quantity be determined by way of cross-sections.

The tendered rate shall include full compensation for procuring and adding the specified material to the layer, for spreading the material, for all haul and other incidentals to add the material to the layer.

Item **Unit**

C10.11 **Milling out existing bituminous material with an average milling depth:**

(a) Not exceeding 30mm……..……cubic metre (m^3)

(b) Exceeding 30mm but not exceeding 60mm…..…cubic metre (m^3)

(c) Exceeding 60mm……..cubic metre (m^3)

Measurement shall be as per pay item 38.02

Item **Unit**

C10.12 **Providing the milling machine on the site** (size indicated).....….number (No)

Measurement shall be as per pay item 38.14

C10.13 **Break down of in-situ material**.....cubic metre (m^3)

The unit of measurement shall be the cubic meter of material measured after compaction. The quantity measured shall be computed by method of average end areas from levelled cross-sections prepared from the existing road surface before any ripping or breaking down of the existing surface and base-course has taken place.

All measurement shall be neat and material placed in excess of the authorized cross-section will not be paid for.

The tendered price shall include the ripping, breaking down, preparing, processing, shaping and watering the materials to the specified densities.

C10.14 **Application of a clear seal……..Litre (L)**

Rates should include the provision of suitable distribution equipment able to apply the clear seal at the specified required rate.