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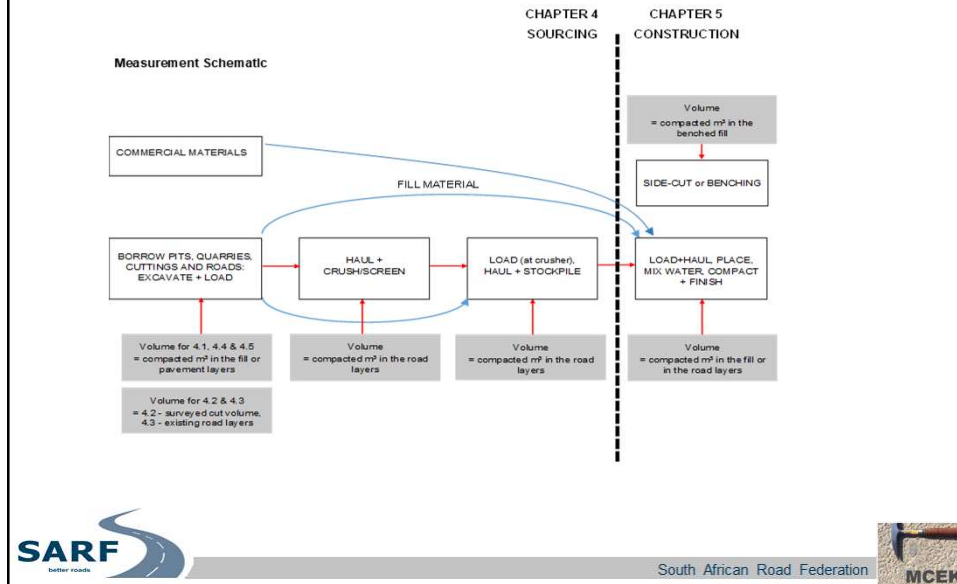
2.1 Review Chapter 4 and
today's programme

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2

Chapters 4 and 5 Link



3

Review of Chapter 4

- History of road specifications
- Overview of the COTO Specifications
- 4.1 – Material definitions and specs
- 4.1 - Sourcing materials borrow pits and quarries
- 1.6 – Clearing and grubbing
- 12.10 – Hard excavation by blasting
- 4.2 – Cut materials
- 4.3 – Existing road materials
- 4.4 – Commercial materials
- 4.5 – Alternative materials

4

Programme for today

- 1.7 – Loading and hauling
- 5.1 – Roadbed
- 5.2 – Fill
- 5.3 – Pavement layers
- 5.4 – Stabilisation
- 5.5 – Reconstruction of layers
- 20.1 – Quality Assurance
- Closure



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2.2. Section 1.7 – Loading and Hauling

Loading and Hauling

List of major changes

1. Loading and Hauling are now two separate pay items.
2. No free-haul anymore.
3. No overhaul anymore.
4. In COTO, only haul.
6. Reason for change: Hauling is often carried out by separate hauling subcontractor.

1.7 LOADING AND HAULING

CONTENTS

PART A:	SPECIFICATIONS
A1.7.1	SCOPE
A1.7.2	DEFINITIONS
A1.7.3	GENERAL
A1.7.4	DESIGN BY THE CONTRACTOR / PERFORMANCE BASED SYSTEMS
A1.7.5	MATERIALS
A1.7.6	CONSTRUCTION EQUIPMENT
A1.7.7	EXECUTION OF THE WORKS
A1.7.8	WORKMANSHIP
PART B:	LABOUR ENHANCEMENT
PART C:	MEASUREMENT AND PAYMENT
PART D:	GUARANTEES AND COMPLIANCE CERTIFICATES

A1.7 LOADING AND HAULING

PART A: SPECIFICATIONS

A1.7.1 SCOPE

This Section covers the loading and hauling of construction materials on the site of the Works.

A1.7.2 DEFINITIONS

Hauling - is the moving of loaded construction material from the point of excavation, or from a stockpile or windrow, to the point of use on the site or to designated spoil areas. The hauling operation shall include the off-loading of the material at the point of use on site, at the temporary stockpiles or at the designated spoil sites as applicable.

Haul roads - are temporary roads constructed by the Contractor, or existing public or privately owned roads, or any part or section of the road under construction, used for the purposes of hauling construction materials or for carting material to spoil.

Loading - is the operation of picking up the material from an excavation, stockpile or windrow and placing it in a haul vehicle.

A1.7.3 GENERAL

A1.7.3.1 Measurement of haul distance (Additional note: When haul is applicable)

The haul distance shall usually be measured from the centre of volume (centroid) of the excavation in the cutting (or part of a cutting), trench or borrow pit, or from the centre of the stockpile position where applicable, to the centroid of the fill (or part of a fill), to the mid-point along the road centreline of the section of the road layer where the material is placed, to the centre of the temporary stockpile position in a borrow pit, quarry or on site or to the centre of the designated spoil area where the material is off loaded as applicable. The haul distance will be measured to the nearest 0,1 km.

For those operations where the material is usually disposed of, and/or reused, near the source of the material the relevant pay item may state that the cost of hauling the material for the first 1,0 km shall be included in the contract rate for that pay item. For these operations the hauling of the material shall only be measured if the actual haul distance exceeds 1,0 km and the haul distance to be measured for payment shall be measured from a point starting 1,0 km from the centre of volume (centroid) of the excavation in the trench or borrow pit, or from the centre of the stockpile position where applicable, up to the centroid of the fill (or part of a fill), up to the mid-point along the road centreline of the section of the road layer where the material is placed or up to the centre of the designated spoil area where the material is off loaded as applicable. The haul distance will be measured to the nearest 0,1 km.

The haul distance shall be measured along the shortest route as instructed by the Engineer as being safe and practical. The haul distance shall include any distance that the haul vehicle must travel to make use of a safe turning point or the next off ramp before making the return trip. Should the Contractor choose to haul material over some other longer route, computations for payment shall nevertheless be based on the haul distance measured along the shortest route instructed by the Engineer. (Additional note: Engineer decides on the shortest route)

A1.7.3.2 Haul and construction access roads

The construction, use and later closure / reinstatement of any haul roads and construction access roads that are required by the Contractor shall be carried out in accordance with the requirements given in Clause A4.1.7.1 of Chapter 4.

The requirements for the use of any existing public roads by the Contractor to haul material are given in Clause A4.1.7.1a).

The requirements for the use of haul roads not on existing public roads are given in Clause A1.2.3.2.

A1.7.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Not required for Section A1.7.

A1.7.5 MATERIALS

Not required for Section A1.7.

A1.7.6 CONSTRUCTION EQUIPMENT

The provisions of Clause A1.2.6 in Section A1.2 shall apply to this Section.

A1.7.7 EXECUTION OF THE WORKS

The loading, hauling, off-loading and spreading of all material shall be carried out in any suitable manner chosen by the Contractor provided no excessive segregation or contamination of the material occurs during any of these operations. If any segregation or contamination that the Engineer determines to be excessive does occur the Contractor shall change his methods of operation to eliminate the excessive segregation or contamination.

In addition to the material origin and destination records, a daily record of the registration numbers, measured level load volumes and the number of trips made by haul vehicles taking material to spoil shall also be kept by the Contractor for all volumes that are measured by loose volume in the haul vehicle. All the daily records shall be submitted to the Engineer no later than 10h00 the following working day. Failure on the part of the Contractor to do so will entitle the Engineer to make his own calculations regarding the volume of material moved as well as the haul distance and the Engineer's calculations will then be final and binding for measurement and payment purposes.

The Contractor shall ensure that the vehicles used to haul construction materials are not overloaded and the legal axle loads are not exceeded. Where specified in the Contract Documentation, the Contractor must provide the Engineer with the certified carrying capacity of each vehicle before any construction materials can be transported.

Unless otherwise specified in the Contract Documentation any truck that is overloaded shall not be allowed to discharge/off-load its load and the overloaded truck shall return to the borrow pit/quarry/depot/batching plant for adjustment of the load. In addition, a penalty shall be applied for the overload. The penalty amount per tonne of overload stated in the Contract Documentation multiplied by the distance that the load was hauled will be deducted on the front page of the payment certificate. Such penalty shall not be deducted from the value of work done in calculating contract price adjustment value.

A1.7.8 WORKMANSHIP

Reserved for future use.

C1.7 LOADING AND HAULING

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, operating, maintaining and decommissioning upon completion, of all the construction equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

(ii) Items that will not be measured separately

The following required activities will not be measured or paid for separately and the Contractor shall include the cost of these activities in other pay items as already specified for the appropriate pay item or as deemed appropriate by the Contractor:

1. The **loading and hauling of commercial materials** from either Employer or Contractor identified suppliers/sources shall not be measured for payment.
2. The **loading of materials on site** will not be measured and paid for separately **except for** loading already stockpiled material and for loading material that has been placed in heaps or windrows where the relevant payment item in other Chapters specifically states that the loading will be paid for separately.
3. The **hauling of materials on site** will not be measured and paid for separately where the relevant payment item specifically states that the hauling operation is included in that payment item.
4. **The hauling of materials on site over a localised distance of up to 1,0 km** will not be measured and paid for separately where the relevant payment item specifically states that the initial haul of the material over a distance of up to 1,0 km is included in the pay item.

(iii) Items to be measured and paid for using items specified elsewhere in the specifications

There are no items mentioned in this section that are measured and paid for elsewhere in this Standard Specification.

(iv) Items specifically for this Section of the specifications

The following payment items will be inserted in the Pricing Schedule under the relevant payment section where loading and/or hauling of materials is applicable. The payment item shall commence with the relevant section number followed by / and then by the applicable loading and hauling payment item numbers given here.

Item	Description	Unit
C1.7.1	Loading	
C1.7.1.1	Loading from stockpile using machines and some hand labour where necessary	cubic metre (m ³)
C1.7.1.2	Loading from heaps or windrows using machines and/some hand labour where necessary	cubic metre (m ³)
C1.7.1.3	Loading by hand only from stockpile or heaps when labour enhancement work is specified or it is not possible to use machines	cubic metre (m ³)

Loading is generally considered to be part of the operation that produced the material which is being loaded, such as excavation, grubbing, cleaning, demolition etc., and it is therefore not usually measured separately for payment. Loading shall only be measured separately for payment for loading stockpiled material and for loading material that has been placed in heaps or windrows where the relevant payment item specifically states that the loading will be paid for separately.

The unit of measurement for items C1.7.1.1 to C1.7.1.3 shall be the cubic metre of material loaded into the hauling vehicles. These pay items shall only apply for those activities where the relevant pay item does not specify that the loading is included in the contract rate for that pay item.

The quantity of all soil and gravel materials loaded for hauling for use on the site of the Works shall be the compacted volume of material measured in its final position in the Works calculated using the dimensions given in the Contract Documentation or specified in writing by the Engineer.

The quantity of all materials loaded for hauling to temporary stockpile for later use in the Works, to borrow pits for backfilling purposes or for disposal at designated spoil areas shall be taken as 70% of the measured load volume of the haul vehicle being used to transport soil and gravel material and 50% of the measured load volume of the haul vehicle being used to transport hard material and/or boulders.

The contract rate for item C1.7.1.1 shall include full compensation for loading material from a stockpile and loading it into the hauling vehicles.

The contract rate for item C1.7.1.2 shall include full compensation for loading excavated material from heaps or windrows at the point of collection, including any windrowing and/or localised sorting / stockpiling that may be required, and loading it into the hauling vehicles.

The contract rate for item C1.7.1.3 shall include full compensation for loading excavated material at the point of collection on site or loading it from stockpile by hand and loading it by hand into the hauling vehicles. This item is only applicable when the Contractor has been instructed to load the material by hand in the Contract Documentation or by the Engineer to enhance the labour component of the Works or if it is not practical to use machines due to the restricted nature of the work.

Item	Description	Unit
C1.7.2	Hauling	
C1.7.2.1	Hauling material for use in the Works and off-loading it on the site of the Works:	
(a)	Soil, gravel, crushed stone and pavement layer material	cubic metre - kilometre (m ³ - km)
(b)	Boulders and hard material	cubic metre - kilometre (m ³ - km)
C1.7.2.2	Hauling material to spoil and off-loading it at a designated spoil or stockpile area:	
(a)	Cleared and grubbed material (organic matter and all other unsuitable or waste material)	cubic metre - kilometre (m ³ - km)
(b)	Soil and gravel material	cubic metre - kilometre (m ³ - km)
(c)	Boulders, hard material and concrete	cubic metre - kilometre (m ³ - km)

The unit of measurement for items C1.7.2.1 and C1.7.2.2 shall be the cubic metre – kilometre (m³ - km) which is calculated as the product of the quantity of material loaded, as measured in items C1.7.1.1, C1.7.1.2 or C1.7.1.3, multiplied by the applicable haul distance which shall be calculated as defined in Clause A1.7.3.1.

These pay items shall only apply for those activities where the relevant pay item does not specify that all the hauling is included in the contract rate for that pay item.

The quantity of all soil and gravel materials hauled **for use on the site of the Works** shall be the **compacted volume of material measured in its final position** in the Works calculated using the dimensions given in the Contract Documentation or specified in writing by the Engineer.

The quantity of all materials hauled **to temporary stockpile** for later use in the Works, to borrow pits for backfilling purposes or to designated spoil areas shall be taken as **70 %** of the measured load volume of the haul vehicle being used to transport soil and gravel material and **50 %** of the measured load volume of the haul vehicle being used to transport hard material and boulders. **(Additional note: Volume of excavation/stockpile and volume of haul may be different. Excavation/stockpile volume can be in place and haul volume a percentage of the truck volume.)**

The quantity of all **organic matter** hauled to borrow pits or to designated spoil areas shall be taken as **50 %** of the measured load volume of the haul vehicle being used.

The contract rate shall include full compensation for hauling the material and off-loading it at the required or designated position.

Loading and Hauling

Summary of major changes

1. Loading and Hauling are now two separate pay items.
2. No free-haul anymore.
3. No overhaul anymore.
4. In COTO, only haul.
5. Payment of haul:
 - 5.1. No payment when to be included in rate.
 - 5.2. No payment for haul less than 1,0 km when the item states accordingly.
 - 5.3. Payment for haul in excess of 1,0 km, only applicable for 5.2.
 - 5.4. Payment for all haul.
6. Pay items that involve loading and/or hauling must state whether measurement and payment is made separately or to be included in the rate of the activity, and for haul which of the 5.2 – 5.4 conditions apply.
7. Verify how quantities of related items are measured, either in place or as a percentage of the loose volume in trucks.

QUESTIONS?

2.3. Section 5.1 – Roadbed

CHAPTER 5: EARTHWORKS AND PAVEMENT LAYERS: CONSTRUCTION

5.1 ROADBED

CONTENTS

PART A: SPECIFICATIONS

- A5.1.1 SCOPE
- A5.1.2 DEFINITIONS
- A5.1.3 GENERAL
- A5.1.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS
- A5.1.5 MATERIALS
- A5.1.6 CONSTRUCTION EQUIPMENT
- A5.1.7 EXECUTION OF THE WORKS
- A5.1.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

A5.1 ROADBED

PART A: SPECIFICATIONS

A5.1.1 SCOPE

This Section covers the work requirements for **normal roadbed treatment**. This is all work in connection with the preparation and compaction of the roadbed, the removal to spoil of material not approved for use in the roadbed and for the replacement of the spoiled roadbed material. Normal roadbed treatment includes dealing with collapsible subgrades, unsuitable material and clay.

Specialist roadbed treatment shall be dealt with in accord with Clause A5.1.3.3.

The following Sections contain relevant specifications for Section A5.1:

- | | | |
|--------------------------------|---|---|
| • Section A1.2 of Chapter 1 | – | General requirements and provisions |
| • Section A1.5 of Chapter 1 | – | Accommodation of traffic |
| • Section A1.6 of Chapter 1 | – | Clearing and Grubbing |
| • Chapter 4 | – | Earthworks and pavement layers: Materials |
| • Section A12.3 of Chapter 12 | – | Ground improvement |
| • Section A12.10 of Chapter 12 | – | Hard excavation by blasting |

A5.1.2 DEFINITIONS

The relevant definitions elsewhere in the standard specifications are applicable. Additional definitions for this Section follow.

Batter - a slope inclined upwards or downwards between the outer edge of a constructed platform area and the outer edge of a second constructed platform area located above or below the first constructed platform. The slope gradient shall be as indicated in the Contract Documentation.

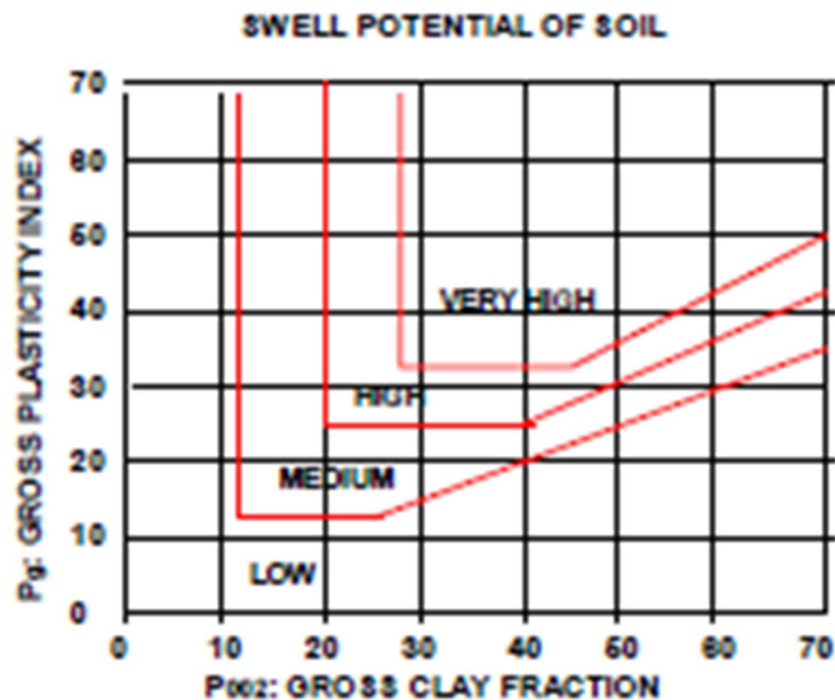
Clay activity - clays are either **inactive, normal or active**. The activity of clay (A) is measured by the ratio of the plasticity index (PI) to the percentage passing the 2µm (P_{0,002}) sieve opening. **Additional note:** This is the Skempton formula.

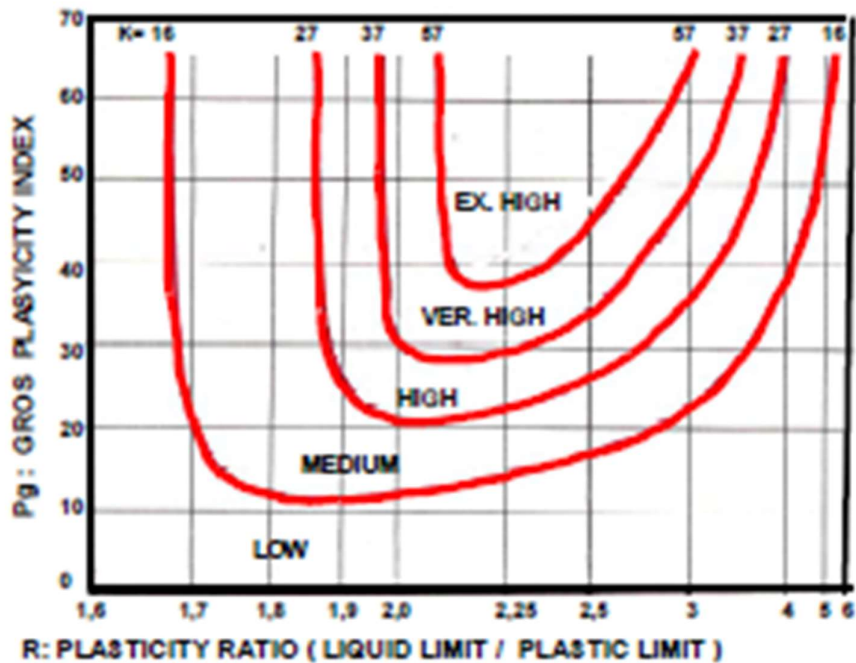
- | | |
|---------------------------|-------------------|
| • A clay is active when | (A > 1,25) |
| • A clay is normal when | (0,75 < A < 1,25) |
| • A clay is inactive when | (A < 0,75) |

Potential expansiveness of clay is also dealt with in **TRH9 (van der Merwe method)**.



Expansive clay longitudinal crack





Collapsing soil or sand - a soil with a collapsible grain structure. It is a soil which can withstand relatively large imposed stresses with small settlements at a low in-situ moisture content, but exhibits a decrease in volume and associated additional settlement with no increase in the applied loading if wetting up occurs. The change in volume is associated with a change in soil structure (the collapse of the grain structure).

Collapse settlement - is the term applied to the additional settlement which occurs due to the wetting up of a partially saturated collapsible soil under load. This collapsing soil phenomenon shall not be confused with consolidation or compaction, since no water is dissipated from the soil, but the collapsing soil absorbs water and progressively loses strength.



Collapse settlement in road after impact rolling

Normal roadbed treatment - normal roadbed treatment is treatment that does not need to be designed by specialist geotechnical engineers nor does it need to be constructed using specialist geotechnical construction equipment.

Roadbed - the constructed, treated or improved natural in place material on which the fill or the pavement layers is constructed directly. The roadbed is constructed prior to the construction of the fill or pavement layers.

Road prism - is the area disturbed during previous or new road construction. The road prism extends between the top of slopes where in cut and between the bottom or toe of slopes where in fill. Where the road cross section is in cut and fill, the road prism shall extend between the top of the cut slope and the bottom or toe of the fill slope. Additionally, the road prism shall include the median width and all side drains when the nearest

edge of the side drain is located within 0,5 m of the top of the cut slope or located within 0,5 m of the bottom or toe of the fill slope.

Roller-pass (conventional roller) - an area will be taken to have received **one roller-pass when a roller has passed over the area once.** Additional passes made as a result of nominal overlapping of at least 200 mm so as to ensure full coverage of the area, shall not be taken into account.

Roller-pass (high-energy impact compactor or roller HEIC) - an area will be taken to have received **one roller-pass when an HEIC has passed over the area twice.** Additional passes made as a result of nominal overlapping of at least 200 mm so as to ensure full coverage of the area shall not be taken into account.

Note: With the continued enhancement of HEIC compaction technology this definition may need to be adjusted or augmented to suit the compaction equipment. Any adjusted definition shall be included in the Contract Documentation.

Side-cut or benching - the excavation of material to form benches or steps. **Suitable excavated material is bladed or placed directly by excavator or dozer into the final position of the material.** The material is used for the construction of a roadbed fill, a fill widening or a backfill behind a retaining structure without it having to be loaded and hauled to the place of final use. Material excavated in this manner is termed side-cut or benching to fill.

Subgrade - the completed earthworks within the road prism before the construction of the pavement layers. This comprises the treated in-situ material of the roadbed and the fill material.

A5.1.3 GENERAL

A5.1.3.1 Roadbed material investigation

The geotechnical information provided in the Contract Documentation for the roadbed reports the results of site investigations including the excavation of test pits and/or drilling, and laboratory tests conducted by or on behalf of the Employer. This provides information as to the quality of the roadbed material and the type of roadbed treatment required.

If not already specified in the Contract Documentation, the Engineer shall instruct the Contractor regarding the different types of normal roadbed treatment or ground improvement, required in terms of Section A5.1 and Section A12.3 of Chapter 12. Normal roadbed treatment excludes specialist roadbed treatment listed in Clause A5.1.3.3.

The Engineer shall give final instructions regarding any additional investigation and testing requirements and the treatment of the roadbed materials prior to the commencement of the programmed roadbed construction period. If any undocumented roadbed conditions are found during construction, the Engineer shall be notified immediately so that any further instructions that may be required, can be issued.

The road prism must be surveyed and correctly staked before any roadbed related operations commence to ensure that the correct extent of roadbed is demarcated for treatment.

A5.1.3.2 Roadbed construction

The Contractor shall take due cognizance when programming roadbed construction as to whether the work may be able to be carried out as full-width construction or if the work may only be able to be done as partial-width construction or carried out under other restrictive conditions.

Clauses C1.1.3.2 and A1.2.3.23 of Chapter 1 are applicable for roadbed construction that takes place as **partial-width construction or takes place under restrictive conditions.** (Additional note: Clause C1.1.3.2 included below.)

b) Rates to include for work carried out under partial width construction conditions and in restricted areas

No additional compensation shall be made for any work that is carried out under partial width construction conditions or is constructed in restricted narrow, short and/or confined areas. Payment shall be made strictly in accordance with the applicable contract rates.

The Contractor shall take full cognizance of all the information given in the Contract Documentation, the nature of the Works and the conditions on the Site of the Works before submitting his contract rates and, in doing so, the Contractor shall ensure that all additional costs associated with partial width construction or construction in restricted narrow, short and/or confined areas, including all costs that are associated with any changes in construction methods or techniques, construction equipment, additional labour and supervision personnel, reduced productivity and increased inefficiencies, are included in the contract rates for the relevant applicable items of work.

This Clause shall apply in full to all pay items except where these requirements may be specifically amended in each case in the Contract Documentation.

A5.1.3.3 Ground improvement or Specialist roadbed treatment

Roadbed ground improvement requiring specialist geotechnical input is dealt with in Section A12.3 of Chapter 12. The various types of ground improvement specified for the roadbed are:

- Geotechnical grouting,
- Jet grouting,
- Compaction grouting,
- Dynamic compaction,
- Rapid impact compaction,
- Vibro-compaction,
- Underpinning,
- Preloading and monitoring, and
- Geosynthetics

A5.1.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Not required for Section A5.1.

A5.1.5 MATERIALS

A5.1.5.1 Remove unwanted material

Prior to construction or treatment of the roadbed, the in-situ roadbed material shall not contain any of the following materials listed hereunder. These unwanted materials shall be removed to a designated spoil site.

- Organic materials, grass and shrubs;
- Wood chippings, tree bark and roots;
- Plastic (bags, polystyrene and so forth);
- Refuse or other non-compliant material;
- Free asbestos; or
- Any of the hazardous material as listed in Clause A4.5.5.5 of Chapter 4.

A5.1.5.2 Topsoil

Topsoil shall be obtained from wherever suitable topsoil material occurs within the road prism ahead of the roadbed construction and within the road reserve as detailed in the Contract Documentation and as specified in Clause A1.6.7.6 of Chapter 1.

A5.1.5.3 Collapsing soil material

The following types of material exhibit a collapsible structure and may form part of the roadbed in some areas as detailed in the Contract Documentation:

- Certain types of Kalahari sands, other aeolian sands and transported sands.
- Some alluvial and sedimentary soils.

Features most commonly associated with collapsible soils include:

- An open soil structure;
- A high void ratio ('void ratio' is the ratio of 'volume of voids to the volume of solids');
- A low dry density;
- A high porosity;
- Geologically young or recently altered deposit;
- Low inter-particle bond strength.

Table A5.1.5-1 provides an **indication of the collapse potential** of a soil in terms of key soil properties.

Table A5.1.5-1: Soil property collapse potential (CP) indicators

Soil Property	CP indicators
Maximum dry density / MDD (kg/m ³)	< 1600
% passing 2,0 mm and retained on 0,075 mm sieve opening	> 60 %
% passing 0,075 mm sieve opening	< 20 %
In place relative density as % of MDD	< 85 %

Where required an inspection pit shall be dug and the material sampled. An undisturbed sample for carrying out a single oedometer test shall be taken. The single oedometer test, also known as the collapse potential (CP) test, shall be performed to assess collapse potential. Table A5.1.5-2 summarises the potential for collapse in terms of the single oedometer test result. **The undisturbed sample for the oedometer test shall be taken at a depth of between 0,8 m and 1,0 m below the material depth** detailed in Table A4.1.5-2 of Section 4.1 of Chapter 4. **(Additional note: Material depths specified in Chapter 4 clause A4.1.5.2.)**

Table A5.1.5-2: Potential for collapse

Test result range for the single oedometer test	Collapse Potential
0 – 1 %	No potential
1 % – 5 %	Moderate potential
5 % - 10 %	Definite potential

Test result range for the single oedometer test	Collapse Potential
10 % - 20 %	Severe potential
> 20 %	Very severe potential

Some collapsing soils exhibit two separate optimum moisture content (OMC) values with two separate maximum dry densities. The collapsibility of these soils is very sensitive to small increases or decreases in compaction moisture content.

A5.1.5.4 Spoil material

The roadbed may contain material that is unsuitable for use because the quality of the material is unacceptable. This material shall be excavated, loaded and hauled to designated spoil sites as instructed by the Engineer. When designated spoil sites are not available temporary spoil stockpiles may be permitted with the prior consent of the Engineer.

The material so removed shall be replaced with fill material or pioneer layer material as instructed by the Engineer.

A5.1.5.5 Pioneer layer material

The properties of material for a pioneer layer are specified in Clause A4.1.5.3 of Chapter 4.

A5.1.5.6 Geosynthetic materials

Reference shall be made to Section A12.11 Geosynthetics of Chapter 12, for the specification, application and types of geosynthetic material to be used for a specific application.

A5.1.6 CONSTRUCTION EQUIPMENT

Construction equipment to carry out roadbed treatment shall comply with the requirements of Clause A1.2.6 of Chapter 1.

High energy impact compactors (HEIC) shall be equipped with functioning continuous impact response metering and GPS when specified in the Contract Documentation.

A5.1.7 EXECUTION OF THE WORKS

A5.1.7.1 Clearing and grubbing

The entire roadbed shall be cleared and grubbed as specified in Section A1.6 of Chapter 1 ahead of any topsoil being removed. Any hazardous material uncovered, shall be disposed of in terms of Clause A1.6.7.7 of Chapter 1.

The clearing and cutting of trees is specified in Section A1.6 of Chapter 1.

The road prism shall be cleared and grubbed 2,0 m wider than the road prism width. Material obtained from clearing and grubbing shall be removed to a temporary stockpile site within the road reserve or removed from site as detailed in the Contract Documentation.

The burning of material on the site of the works shall not be permitted.

Areas within an existing road prism will normally not require clearing and grubbing.

The removal of buildings and structures is specified in Section A1.6 of Chapter 1 and the removal of materials generally found in urban areas such as kerbs, road-edging, utility structures and paved sidewalks are specified in Section A4.3 of Chapter 4.

A5.1.7.2 Removal and conservation of topsoil from roadbed

After clearing and grubbing, topsoil shall be excavated and stockpiled as specified in Section A1.6 of Chapter 1, but only after the Engineer has confirmed that the removal of topsoil and the stockpiling thereof, is required.

The topsoil shall be excavated and stockpiled for later top-soiling of the fill and cut slopes. The requirements of Section A1.6 of Chapter 1 for the removal of topsoil shall be complied with.

A stockpile site shall be prepared at the designated area prior to removing any of the required topsoil in accordance with the provisions of Clause A4.1.7.3 of Chapter 4.

Topsoil shall be stockpiled in separate loose heaps not exceeding 2,0 m in height, unless specified otherwise in the Contract Documentation. The haul trucks shall not be driven over the top soil material and any compaction of the topsoil shall not be permitted.

A5.1.7.3 Normal roadbed treatment

a) Construction overview

The method of processing and compacting the roadbed and fill material as part of normal roadbed treatment, or the class of compaction, shall be specified in the Contract Documentation or be instructed by the Engineer in advance.

The classification of material as hard material or in the case of LEC, intermediate material, to compensate the Contractor for the cost of excavation thereof, shall not be taken into consideration for any additional compensation when used in the compacted fill.

When the roadbed to be treated is located on a slope that is steeper than 1 (one) vertical to 10 (ten) horizontal, the roadbed treatment shall be benched as specified in Clause A5.2.7.3 and in the Contract Documentation. The minimum depth of the specified roadbed treatment shall be complied with for the full extent of the treatment.

Ground improvement roadbed treatment is not normal roadbed treatment, but specialist roadbed treatment and is specified in Chapter 12.

b) Removal of unsuitable roadbed material

(Additional note: Definitions of Unsuitable, Stable and Unstable material in Chapter 4 clause A4.1.2.)

Any roadbed material which is of unsuitable quality shall be removed to spoil to such widths and depths as instructed by the Engineer. The unsuitable material shall be disposed of as detailed in the Contract Documentation or as instructed by the Engineer. The excavated roadbed material shall then be replaced with approved, imported fill material, compacted to the specified density.

The Engineer may instruct that material that is unsuitable due to being unstable be removed and replaced with approved material. The Contractor shall implement adequate temporary drainage measures as per instruction from the Engineer, ahead of the removal to spoil of the unstable material. The instruction by the Engineer must clearly state the depth of the material to be removed, contain an assessment in respect of the stability of the material and ensure that suitable construction equipment is available.

After completion of the removal of any unstable material to the specified line and depth in accordance with the Engineer's instructions, it may still be necessary to remove some stable material. This material will also be classified as 'unstable' material, for measurement and payment purposes only, if the thickness of the stable material to be removed is less than 200 mm. If the thickness to be removed exceeds 200 mm then the stable material will remain classified as stable material taken to spoil.

c) Percentage of maximum dry density (MDD)

Any section of the roadbed material that is classified as being suitable for use in-situ, but the material fails to meet density requirements, shall be scarified, watered and compacted to the depth and to the percentage of MDD specified in the Contract Documentation. In the absence of a specified depth, the depth of roadbed treatment shall be 150 mm. If necessary, roadbed material may have to be scarified and temporarily bladed to windrow to allow for compaction in layers in order to achieve the specified compaction density throughout the specified depth of treatment.

Where any additional material has to be imported to make up the required level and layer thickness, and where the thickness of the layer of imported material would be less than the specified layer thickness after compaction, then the roadbed material shall first be scarified. The additional imported material shall then be placed, blended with the scarified roadbed material and compacted to the full specified depth of that roadbed layer.

d) Roller-pass compaction

Where the percentage compaction cannot be satisfactorily determined by way of testing the in-situ density due to the nature of the material, the Engineer shall instruct that the material be compacted by a specified number of passes. The number of passes shall be carried out by a single type of roller or by a combination of various types of rollers. The Engineer shall issue instructions regarding the required number of passes for each type of roller being used.

A trial section shall be constructed to determine the best type of rollers or combination of rollers and the required number of roller-passes for each roller being used.

The Contractor shall use one, or a combination of any, of the following rollers:

- Grid roller;
- Impact roller;
- Pad-foot vibratory roller;
- Smooth drum vibratory roller;
- Pneumatic roller;
- High energy impact compactor (HEIC); or
- Any other suitable roller.

This roller-pass compaction shall normally be carried out at the in-situ moisture content. No rigid control of the moisture content will be exercised during compaction. The Contractor shall nevertheless prove to the Engineer that every possible endeavour is being made to take advantage of favourable soil-moisture conditions and to carry out such roller-pass compaction in so far as is possible during periods when the roadbed is neither excessively dry nor excessively wet.

The Contractor shall consult the Engineer as to when conditions are favourable for compaction and where such compaction shall be done at any particular time. The Engineer shall instruct and then compensate the Contractor to water the roadbed when the roller-pass compaction cannot be programmed to be carried out at a time when acceptable moisture conditions exist.

e) Compaction of collapsible soil

(i) General

The type of treatment of any portion of the roadbed that has a collapsible soil structure shall be specified in the Contract Documentation.

(ii) Soil collapse construction

The measurable criteria to confirm that soil collapse has taken place, such as percentage of MDD, the in-situ measured CBR (by DCP), the amount of collapse settlement and so forth, shall be specified in the Contract Documentation.

(iii) Non wetting-up roadbed collapse

The non wetting-up collapsible roadbed material;

- The material can be **compacted in-situ using conventional rollers and/or HEIC rollers**. The soil shall be collapsed at the **in-situ moisture content**.
- The material to be collapsed can alternatively be temporarily excavated to stockpile and then imported from the stockpile in controlled compacted layers.

A trial section shall monitor and establish all or some of the following criteria as specified in the Contract Documentation.

- The existing in-situ DCP-determined CBR strength (pre-construction);
- Confirm the compaction equipment or combination of compaction equipment required;

- A correlation between settlement, density and DCP-determined CBR strength for compaction control;
- The minimum required number of compaction passes to ensure collapse settlement;
- The moisture content and the percentage of MDD; and
- The DCP-determined CBR (post-construction) at the depth specified.

(iv) Wetting-up roadbed collapse

The wetting-up and compaction of a roadbed trial section for the collapse thereof shall be divided into construction phases:

- Determine the pre-construction moisture contents and then after each controlled addition of water.
- All moisture contents are to be determined along the length and the full collapse depth of the trial section. This is to establish and verify uniform moisture sections for collapse treatment;

The trial section shall monitor and establish all or some of the following criteria as specified in the Contract Documentation:

- The existing in-situ DCP-determined CBR strength at different depths (pre-construction);
- Determine the moisture contents and DCP-determined CBR strengths after completion of each wetting and compaction cycle during the construction of the trial section;
- Establish the amount of vertical settlement or collapse by taking sufficient levels before, after completion of each wetting-up/compaction phase and after the completed construction of the trial section for each uniform moisture section.
- The minimum required number of compaction passes, compaction equipment and moisture content required to ensure compliance with the specified collapse settlement and/or the required DCP-determined CBR, post-construction.

f) Hard material

Where detailed in the Contract Documentation, or as instructed by the Engineer, the roadbed shall be treated in-situ by breaking up formations of hard materials in order to achieve a uniform standard of compaction and to improve the subsurface drainage ahead of the fill or the road pavement layers.

Treatment in-situ shall consist of ripping the roadbed, or drilling and blasting the roadbed using explosives, or drilling and splitting the roadbed using non-explosive, expansive, rock-breaking products. The depth of ripping or drilling shall increase uniformly from the centre of the roadbed to the edges, on cambered sections of road.

(i) In-situ treatment by ripping

Unless indicated otherwise in the Contract Documentation, or instructed by the Engineer, the depth of ripping in the centre of the roadbed shall not be less than 300 mm and at the edges of the roadbed not less than 500 mm.

On super elevation sections or cross-fall sections the in-situ treatment shall have a cross-fall parallel to the pavement cross-fall and a uniform minimum depth of 400 mm.

Shales and mudstones shall also be treated in-situ as described above or removed to the required depth if so specified in the Contract Documentation.

After ripping, the hard roadbed material shall be broken down by rolling until the maximum dimension of any material fragment does not exceed 200 mm. The material shall then be compacted by means of a specified number of passes by a selected type of roller or by a combination of various rollers.

(ii) In-situ treatment by drilling and rock breaking

Unless indicated otherwise in the Contract Documentation, or instructed by the Engineer, the depth of drilling and rock breaking shall not be less than 700 mm at the centre of the roadbed and not less than 1000 mm at the edges of the roadbed.

On super elevation sections or cross-fall sections, the in-situ treatment shall have a cross-fall parallel to the pavement cross-fall with a minimum depth of 850 mm.

After drilling and rock breaking, the hard roadbed material shall be broken down by rolling until the maximum dimension of any material fragment does not exceed 200 mm. The material shall then be compacted as specified by means of a number of roller-passes using a selected type of roller or a combination of various rollers. The Contractor shall determine the drilling pattern to ensure that the amount of breaking down required during compaction is less than 5 %.

Any surplus material resulting from bulking after in-situ treatment, shall be removed and disposed of or utilized elsewhere as directed by the Engineer.

g) Inactive clay and normal clay

Inactive clays and normal clays in the roadbed that **heave or settle during a three roller-pass trial compaction shall be treated using one of the following three methods, as specified in the Contract Documentation.**

A trial section shall be constructed of the specified roadbed treatment, to clearly establish the construction technique to be applied as well as to confirm the correct construction equipment and the required number of roller-passes required.

The trial section shall also clearly establish the visual and/or laboratory testing to be done. Upon completion of the trial section the Engineer shall instruct the Contractor regarding the type and amount of testing.

(i) Material modification

The in-situ roadbed material shall be shaped to line and level. A layer of approved material, thickness as specified in the Contract Documentation, shall be imported and spread out across the top of the pre-shaped roadbed.

The imported layer shall be thoroughly blended with the inactive/normal clay to the depth as specified in the Contract Documentation using appropriate construction equipment and then compacted to comply with the specified MDD or to comply with the specified number of roller-passes and compaction requirement.

(ii) Lime modification

The in-situ roadbed material shall be shaped to line and level. The amount of road lime shall be as specified in the Contract Documentation. This amount shall not be less than 2 % by weight. The road lime shall then be evenly spread over the shaped roadbed. Laboratory testing prior to construction shall establish the required lime content and the ideal maturing period to achieve a maximum reduction of the plasticity index (PI). The Engineer shall then instruct the Contractor accordingly.

The lime shall be mixed in-situ into the roadbed material to the specified depth in the Contract Documentation or as instructed by the Engineer using a suitable rotovator or recycling machine or by making use of other appropriate construction equipment such as a motor grader and plough. The thickness of mixing should be limited to a maximum of 200 mm. Adjacent mixing strips shall be overlapped by at least 150 mm to avoid any material not being treated.

During initial mixing and pulverisation, it may be necessary to add water when the in-situ material is below OMC, in order to ensure that the lime modifies the material.

Following each mixing pass the material shall be trimmed and lightly compacted using single roller-pass compaction or as instructed by the Engineer, with a smooth wheeled roller or pneumatic tyre roller or other suitable roller as determined during the construction of a trial section, in order to ensure the correct processing depth throughout the operation. Once initial mixing and the addition of water is complete, the material shall be trimmed and lightly compacted with two roller-passes and then left for a maturing period which shall be between 24 hours and 72 hours as determined by the laboratory.

Following the maturing period, re-mixing and the final moisture content adjustment shall take place. The moisture content should be as close as possible to the OMC for the material. The roadbed material shall then be compacted to either the specified MDD or to the specified roller-pass compaction requirement.

(iii) Removal of material

The clay material shall be removed and replaced with approved material to a maximum depth of 450 mm as specified in the Contract Documentation. The approved material shall be compacted to the specified MDD.

h) Active clay

Treatment of active clays shall be by means of Alternative 1 or by means of Alternative 2 hereunder. The method to be used shall be as specified in the Contract Documentation or as instructed by the Engineer.

(i) Alternative 1 - Roadbed construction using lime

Laboratory testing prior to construction shall confirm the required lime content and the ideal maturing period in terms of the maximum reduction of the plasticity index (PI).

A trial section shall then be constructed to clearly establish the construction technique to be applied as well as to confirm the correct construction equipment to be used and the required number of roller-passes.

The in-situ material shall be shaped to line and level for the section of roadbed with active clay and the roadbed shall then be processed in 3 phases as specified below.

- **Phase 1 Mix first 50 % of lime**

The section of in-situ roadbed with active clay shall be ripped to a depth of 250 mm or to a depth as specified in the Contract Documentation and 50 % of the required total road lime content, as determined by the laboratory testing, shall then be mixed in to the full depth using a rotovator or a recycling machine. Due to the nature of active clay the use of a motor grader and/or plough will not achieve the required degree of mixing when used on their own. During this mixing process the Contractor shall ensure that all the clods of clay are broken down. If necessary, a pad foot roller can also be used to help break up the clay clods.

After the mixing and breaking down process has been completed, water must be added if required, to ensure that the moisture content shall be close to 50 % of the optimum moisture content. The layer shall then be sealed with a single roller-pass compaction using the appropriate roller as established during the construction of a trial section.

- **Phase 2 Maturing period**

The treated roadbed clay material shall then be left for at least 48 hours or any longer period as determined by the laboratory to allow the first amount of lime to react with the material to make the material more workable.

- **Phase 3 Mix balance of lime and compact**

After the maturing period, spread the remaining 50 % of the lime, rip the 250 mm thick roadbed layer and mix in the lime using a rotovator, a recycling machine or a grader and plough as determined during the construction of a trial section.

After this mixing process has been completed water must be added to ensure that the moisture content shall be close to 50 % of the optimum moisture content. The roadbed material shall then be compacted as specified in the Contract Documentation or as instructed by the Engineer after construction of a trial section.

During the final compaction process the roadbed layer shall be shaped to the correct design levels and camber or cross-fall to ensure that the compacted surface is able to drain. No low spots shall exist where water can be trapped beneath the fill on top of the compacted and treated active clay roadbed material.

(ii) Alternative 2 - Roadbed construction by removal of active clay

The heaving clay in the roadbed shall be removed down to the bottom of the clay layer, or to a minimum depth of 750 mm below natural ground level, or to a depth as specified in the Contract Documentation. The material shall be loaded, hauled and then off-loaded at a designated spoil site.

The removed material shall be replaced with compliant material and be compacted to the specified percentage of MDD as per the Contract Documentation.

Moisture content fluctuations for both alternatives within the road prism must be restricted. This shall be achieved by constructing a flattened side batter such as 1 (vertical):3 (horizontal), or by placing and compacting additional clay material adjacent to the standard road side batter as detailed in the Contract Documentation.

i) Construction of a pioneer layer

Where fill is to be constructed across water-logged or soft clayey ground, that exhibits excessive movement under normal compaction equipment and haulage trucks (unstable material), and such conditions preclude the effective compaction of the bottom fill layers, or the effective removal of the material to spoil, a pioneer layer shall be constructed directly over this material as detailed in the Contract Documentation or as instructed by the Engineer. The pioneer layer shall be constructed by dumping successive loads of material compliant with Clause A4.1.5.3 of Chapter 4 and spreading the material uniformly to a thickness which is just sufficient to provide a stable working platform for constructing the subsequent fill layers.

Appropriate light hauling equipment shall be used and end-tipping shall be employed for placing the material. The layer shall be compacted by using suitable compaction equipment without the water-logged roadbed material being overstressed. Pioneer layers shall not require compaction to a controlled density.

Upon completion of the construction of the pioneer layer, the construction of a levelling course layer with an average compacted thickness of 200 mm shall normally be required to be constructed to line and level, using compliant fill material. The compacted density of the layer shall be as instructed by the Engineer, but no more than a density of 90 % MDD.

A5.1.7.4 Special drainage measures, dewatering

Any waterlogged roadbed, such as saturated material overlying less pervious strata, shall first be drained by the installation of all permanent surface and/or subsoil drainage detailed in the Contract Documentation or as directed by the Engineer, before any other construction may commence on these sections.

A5.1.7.5 Dolomitic roadbed treatment

In dolomitic areas the roadbed treatment by the construction of a soil raft, or by any other appropriate treatment measure, shall be specified in the Contract Documentation by a geotechnical Engineer.

A5.1.8 WORKMANSHIP

A5.1.8.1 Inspection of the works

The Engineer shall do routine inspections and conduct routine tests to determine whether the quality of material and workmanship provided, complies with the requirements of the Contract Documentation.

A5.1.8.2 Compaction requirements

Compaction compliance shall be determined as follows:

- The in-situ measured density of the roadbed treatment complies with the specification when the results of at least 75 % of the in-situ density tests, located as per the Contract Documentation of any lot, are equal to or exceed the specified values and no single density is more than 5 percentage points below the specified value.
- The roller-pass roadbed treatment complies with the specification when the agreed number of roller-passes have been observed and recorded as being the same as that of the accepted trial section.
- The roadbed treatment of collapsing soils complies with the specification when the compaction of the collapsing soils is verified to yield the same agreed results as obtained in the accepted trial section.
- The hard material roadbed treatment complies with the specification when the depth of blasting or ripping is confirmed as being in accordance with the specification and the layer has been monitored and confirmed as being fully functional in terms of sub-surface drainage.
- There are no compaction density requirements for the pioneer layer. The pioneer layer complies with the requirements of the specifications when movement or heaving of the pioneer layer under the load of conventional compaction equipment or of loaded haulage trucks has ceased.
- The in-situ measured density of the levelling layer is compliant when results of at least 75 % of the in-situ density tests, located as per the Contract Documentation, of any lot, are equal to or exceed the specified values and no single density is more than 6 percentage points below the specified value.

A5.1.8.3 Construction tolerances

The roadbed shall be constructed to the dimensional tolerances specified below. (Additional note: Roadbed now also has construction tolerances.)

a) Levels

The level tolerances shall be as follows for the top of the roadbed.

In cases where the in-situ treatment of the roadbed supports a fill of more than 500 mm thick, the levels of the top of the treated roadbed shall not be subject to any level tolerances other than that the roadbed shall at no point encroach more than 200 mm into the fill.

In cases where the in-situ treatment of the roadbed is beneath a fill of less than 500 mm thick, the levels of the top of the treated roadbed shall at no point encroach more than 50 mm into the fill.

In cases where the in-situ treatment of the roadbed is in a cutting, irrespective of the type of material in the roadbed, and the pavement layers are constructed directly on top of the treated roadbed, the treated roadbed shall be subject to the following tolerances as applied to the specified design levels:

$$H_{90} = \pm 25 \text{ mm}$$

$$H_{\max} = \pm 35 \text{ mm}$$

b) Width

The horizontal measurement taken from the centre line of the road to the edge of the roadbed treatment shall nowhere be 250 mm more than the specified dimension when measured at roadbed level and nowhere should it be less than the specified dimension.

C5.1 ROADBED

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the construction plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Classification of materials for labour enhancement

Where excavation is done using labour enhancement methods, the Engineer shall classify excavated materials either as soft or intermediate, in terms of Tables C5.1-1 and C5.1-2.

No hard material shall be measured under labour enhancement methods.

Table C5.1-1: Classification of excavated materials for labour enhancement

MATERIALS CLASSIFICATION	DESCRIPTION
Soft	Material which can be excavated by means of a suitable shovel with or without the use of a pick or other hand-swung tool
Intermediate	Material which is difficult to excavate by hand even with the aid of a crowbar and requires the assistance of pneumatic tools for economic removal.

Table C5.1-2: Classification of materials in terms of consistency and shear strength for labour enhancement

MATERIALS CLASSIFICATION	CONSISTENCY		NUMBER OF DCP BLOWS TO PENETRATE 100 mm *	
	Granular soil	Cohesive soil	Granular soil	Cohesive soil **
Soft	Very loose to dense	Very soft to stiff	≤ 15	≤ 8
Intermediate	Very dense	Very stiff	>15	>8
*Only applicable to materials comprising not more than 10 % gravel of size less than 10 mm and materials containing no cobbles or isolated small boulders.				
**This could be subjective depending on the moisture content of the cohesive material				

(iii) Items that will not be measured separately

The following required activities will not be measured or paid for separately and the Contractor shall include the cost thereof in other items as deemed appropriate:

1. Staking of the road prism referred to in Clause A5.1.3.1.
2. Drainage and protection of the pavement layers from all damage that may occur for any reason until the Employer has taken over the Works.
3. Protection and repair as required of all existing and new roadside furniture, of all existing and new drainage structures and of all existing and new infrastructure until the Employer has taken over the Works
4. Protection and repair as required of any other items adjacent to, over or under the road that are damaged by the Contractor's vehicles, and equipment, or by public traffic being accommodated on or alongside the Works, during the construction of the Works.
5. Repair of all damage to any new or existing structures, buildings, road furniture and services that may occur for any reason before, during or after the construction of the roadbed up until the Employer has taken over the Works.
6. Provision of and/or the subsequent removal of all excess material after completion of the roadbed treatment.

(iv) Work in restricted areas

Clause C1.1.3.2b) of Chapter 1, specifies that all rates are to be inclusive.

(v) **Items to be measured and paid for using payment items specified elsewhere in the specifications**

For activities in Table C5.1-3 payment items specified in other Chapters or Sections of the specification, where they relate to work under this Section, will be listed in the Pricing Schedule.

Table C5.1-3: Payment items from other Chapters or Sections

Activity	Section 5.1 reference	Section item reference
Ground improvement (Specialist Roadbed Treatment)	A5.1.3.3	Section C12.3 of Chapter 12 – All applicable items
Remove unwanted material	A5.1.5.1	Section C1.6 of Chapter 1 – All applicable items
Topsoil	A5.1.5.2 / A5.1.7.2	Section C1.6 of Chapter 1 – All applicable items
Additional laboratory testing	A5.1.3.1 / A5.1.7.3	Section C4.1 of Chapter 4 – All applicable items
Loading and hauling material	A5.1.5.4 / A5.1.7.3	Section C1.7 of Chapter 1 – All applicable items
Clearing and grubbing	A5.1.7.1	Section C1.6 of Chapter 1 – All applicable items
Construction of stockpile site	A5.1.7.2	Section C4.1 of Chapter 4 – All applicable items
Fill material	A5.1.7.3b)	Section C5.2 of Chapter 5 – All applicable items
Hard material excavation	A5.1.7.3f)	Section C12.10 of Chapter 12 – All applicable items
Lime modification	A5.1.7.3g)	Section C5.4 of Chapter 5 – All applicable items
Drainage	A5.1.7.4	Section C3.1 of Chapter 3 – All applicable items

(vi) **Determining the quantities**

(Additional note: Three sets of cross sections to be taken by the Contractor at no cost to the Employer.)

- 1. Before carrying out any construction work in connection with clearing and grubbing and the removal of topsoil,** the Contractor, shall at no cost to the Employer, take cross-sections at a maximum spacing of 20 m so as to determine the original ground line.
- 2. After completion of the topsoil removal** the Contractor, shall at no cost to the Employer, take cross-sections at a maximum spacing of 20 m so as to determine the new ground line and subsequently the quantities of topsoil removed ahead of the commencement of the roadbed treatment.
- 3. After completion of the roadbed treatment** the Contractor, shall at no cost to the Employer, take cross-sections at a maximum spacing of 20 m so as to determine the final roadbed levels and subsequently the quantities of any roadbed levelling operations, if any, ahead of the cut to fill operations commencing.

The Engineer shall take control measurements to determine the accuracy and adequacy of the cross-sections, and shall instruct the Contractor to correct any out of tolerance work and to take such additional measurements and cross-sections as may be deemed necessary. Such cross-sections shall be taken before any cut or fill work is done.

Where the Contractor proceeds with further construction work before the Contractor and the Engineer have reached agreement on the accuracy and adequacy of the cross-sections, the Engineer's decision regarding the cross-sections to be used shall be final and binding on the Contractor.

(vii) **Material from commercial sources**

Where specified in the Contract Documentation, material from commercial sources shall be used for the construction of roadbed treatment. In such cases the items listed below shall be applicable, except that the tendered rates shall also include full compensation for all transport costs as no load and haul shall be measured for commercial material.

(viii) **Payment items specifically for this Section of the specifications**

Item	Description	Unit
C5.1.1	Roadbed construction and compaction	
C5.1.1.1	Compaction of in-situ material to 90 % of MDD	cubic metre (m ³)
C5.1.1.2	Compaction of in-situ material to 93 % of MDD	cubic metre (m ³)
C5.1.1.3	Compaction of imported material to 90 % of MDD	cubic metre (m ³)
C5.1.1.4	Compaction of imported material to 93 % of MDD	cubic metre (m ³)
C5.1.1.5	Compaction of in-situ sand roadbed to 95 % of MDD	cubic metre (m ³)
C5.1.1.6	Compaction of in-situ sand roadbed to 100 % of MDD	cubic metre (m ³)

The unit of measurement shall be the cubic metre of roadbed material prepared and compacted as specified. The quantity of the in-situ material

shall be computed in accordance with the authorised dimensions of the completed layers. The quantity of imported material shall be measured in the haul vehicles, by taking the volume of the imported material to be the equivalent of 70 % of the loose volume in the haul vehicles.

The tendered rates for items C5.1.1.1, C5.1.1.2, C5.1.1.5 and C5.1.1.6 shall include full compensation for shaping, scarifying, mixing of in-situ material and preparing and compacting the material to the specified MDD.

The tendered rates for items C5.1.1.3 and C5.1.1.4 shall include full compensation for shaping, scarifying with in-situ material where required and mixing of the imported material or the in-situ/imported material blend, then preparing and compacting the material to the specified MDD.

The tendered rates for items C5.1.1.3 and C5.1.1.4 shall include for loading and off-loading the imported material. The haul of the imported material shall be measured from the point of loading until the point of off-loading as per Section A1.7 of Chapter 1.

(Additional notes: 1. Payment in these two items is to replace unsuitable material in the roadbed, to make up for settlement and for adjusting of levels. 2. Payment for sourcing the imported material is to be made in Chapter 4 Section 4. 3. Only the construction with the imported material is in these two items. 4. No payment for load and haul of commercial material.)

(Additional note: Compaction of a roadbed in collapsing soil in item C5.1.8)

All material that requires being imported for the construction of the roadbed, to replace spoil material measured under item C5.1.2, or to replace unsuitable material measured under C5.1.3, except the levelling layer which shall be paid under item C5.1.12, shall be measured and paid for under this item C5.1.1.

Item	Description	Unit
C5.1.2	Excavate material to spoil sites designated by the Employer	
C5.1.2.1	Excavate material to spoil from roadbed construction, material obtained from:	
(a)	Soft excavation	cubic metre (m ³)
(b)	Boulder excavation Class A	cubic metre (m ³)
(c)	Boulder excavation Class B	cubic metre (m ³)
(d)	Hard excavation (other than by blasting)	cubic metre (m ³)
(e)	Hard excavation (by blasting)	cubic metre (m ³)
C5.1.2.2	Excavate material to spoil from roadbed construction, using labour enhancement, material obtained from:	
(a)	Soft excavation	cubic metre (m ³)
(b)	Intermediate excavation	cubic metre (m ³)

The unit of measurement shall be the cubic metre of material measured in its original position in cut and computed by the method of average end areas from levelled cross-sections taken as specified.

Where measurement by cross-sections is considered by the Engineer to be impractical, cut to spoil may be measured in the haul vehicles, by taking the in situ volume of the material to be the equivalent of 70 % of the loose volume in the haul vehicles.

For payment purposes a distinction shall be made between using conventional construction methods and using labour enhancement.

The tendered rates of item C5.1.2.1 shall include full compensation for excavating and loading from the road prism and roadbed the material in the different classes of excavation. Haul shall be measured and paid for from the point of loading to the point of off-loading.

The tendered rates of item C5.1.2.2 shall include full compensation for using labour enhancement for excavating and loading from the road prism and roadbed in the different classes of excavation. Haul shall be measured and paid for from the point of loading to the point of off-loading.

The excavation of hard material by blasting shall exclude the cost of blasting which shall be measured and paid for under item C12.10.1 in Section C12.10 of Chapter 12.

Item	Description	Unit
C5.1.3	Excavate material to spoil sites designated by the Contractor	
C5.1.3.1	Excavate material to spoil from roadbed construction, material obtained from:	
(a)	Soft excavation	cubic metre (m ³)
(b)	Boulder excavation Class A	cubic metre (m ³)
(c)	Boulder excavation Class B	cubic metre (m ³)
(d)	Hard excavation (other than by blasting)	cubic metre (m ³)
(e)	Hard excavation (by blasting)	cubic metre (m ³)

C5.1.3.2 Excavate material to spoil from roadbed construction, using labour enhancement, material obtained from:

- | | |
|-----------------------------|-------------------------------|
| (a) Soft excavation | cubic metre (m ³) |
| (b) Intermediate excavation | cubic metre (m ³) |

The unit of measurement shall be the cubic metre of material measured in its original position in cut and computed by the method of average end areas from levelled cross-sections taken as specified.

Where measurement by cross-sections is considered by the Engineer to be impractical, cut to spoil may be measured in the haul vehicles, by taking the in situ volume of the material to be the equivalent of 70 % of the loose volume in the haul vehicles.

For payment purposes a distinction shall be made between using conventional construction methods and using labour enhancement.

The tendered rates of item C5.1.2.1 shall include full compensation for excavating and loading from the road prism and roadbed the material in the different classes of excavation. All haul costs shall be included in the tendered rates for item C5.1.3..

The tendered rates of item C5.1.2.2 shall include full compensation for using labour enhancement for excavating and loading from the road prism and roadbed in the different classes of excavation. All haul costs shall be included in the tendered rates for item C5.1.3..

The excavation of hard material by blasting shall exclude the cost of blasting which shall be measured and paid for under item C12.10.1 in Section C12.10 of Chapter 12.

Item	Description	Unit
C5.1.4	Removal of unsuitable material to spoil	
C5.1.4.1	In layer thicknesses of 200 mm and less	
(a)	Stable material	cubic metre (m ³)
(b)	Unstable material	cubic metre (m ³)
C5.1.4.2	In layer thicknesses exceeding 200 mm	
(a)	Stable material	cubic metre (m ³)
(b)	Unstable material	cubic metre (m ³)

The unit of measurement shall be the cubic metre of unsuitable material removed by the Contractor to spoil in accordance with the Engineer's instructions, and it shall be the in-situ volume of the material calculated in accordance with the authorised dimensions. Where the use of authorised dimensions proves to be unsatisfactory, then the unit of measurement shall be 70 % of the loose volume measured in the haul trucks.

The tendered rates shall include full compensation for excavating and loading the material from the road prism and roadbed in the different classes of excavation.

Hauling shall be measured and paid for from the point of loading to the point of off-loading as per Section C1.7 of Chapter 1.

The removal of unsuitable stable material in cuttings is measured and paid for under item C4.2.7 of Chapter 4.

Item	Description	Unit
C5.1.5	In-situ treatment of roadbed in hard material	
C5.1.5.1	In-situ treatment by ripping	cubic metre (m ³)
C5.1.5.2	In-situ treatment by drilling and blasting	cubic metre (m ³)
C5.1.5.3	In-situ treatment by drilling and splitting the material using non-explosive, rock-breaking products	cubic metre (m ³)

The unit of measurement shall be the cubic metre of material treated in-situ as specified. The quantity shall be calculated from the authorised dimensions of the in-situ treatment.

The tendered rates for items C5.1.5.1 and C5.1.5.2 shall include full compensation for ripping or for drilling and blasting, shaping, scarifying, sizing, mixing of in-situ and imported material if required, processing and compacting the material as specified. Payment shall distinguish between in-situ treatment by ripping only and in-situ treatment by drilling and blasting.

The excavation of hard material by blasting for item C5.1.5.2 shall exclude the cost of blasting which shall be measured and paid for under item C12.10.1 in Section C12.10 of Chapter 12.

The tendered rates for item C5.1.5.3 shall include full compensation for drilling the holes, procurement of the rock-breaking product(s), charging the drilled holes and splitting the material. The tendered rates shall also include for shaping, scarifying, sizing, mixing of in-situ and imported material if required, processing and compacting the material as specified.

All imported material shall be measured and paid for under Section C5.2.

No separate payment shall be made for oversize or surplus material excavated to spoil as a result of this treatment.

Surplus material shall be measured and paid under item C5.1.1 if used in the roadbed.

Item	Description	Unit
C5.1.6	Roller-pass compaction	
C5.1.6.1	Grid rollers	square metre (m ²)
C5.1.6.2	Pad foot vibratory rollers	square metre (m ²)
C5.1.6.3	Smooth drum vibratory rollers	square metre (m ²)
C5.1.6.4	Other vibratory rollers. Specify.....	square metre (m ²)
C5.1.6.5	Impact rollers	square metre (m ²)
C5.1.6.6	Pneumatic rollers	square metre (m ²)
C5.1.6.7	High energy impact compactor/roller (HEIC)	square metre (m ²)
C5.1.6.8	Other rollers. Specify.....	square metre (m ²)

The unit of measurement shall be the square metre of roadbed compacted in accordance with the specification for a single roller-pass. The quantity will be measured in accordance with the authorised dimensions of the area to receive single roller-pass compaction.

The area to be roller-pass treated will be adjusted to be commensurate with the number of roller-pass treatments instructed. The authorised area will be doubled when two roller-pass compaction is specified or trebled when three roller-pass compaction is specified in the Contract Documentation, or instructed by the Engineer, and so forth. **(Additional note: Unit different from the COLTO square metre-pass, but will give the same answer)**

The tendered rates shall include full compensation for shaping, providing the rollers, keeping the rollers operational and ready for when soil-moisture conditions are favourable, and for compacting the roadbed with the specified number of roller-passes.

The Contractor shall base the tendered rates on a single, one direction pass for each specified type, size and weight of roller. The area covered by the nominal roller overlap width required to ensure full coverage of the area being compacted shall not be measured for additional payment. If the rollers available on site are different types, sizes and weights than those specified in the Contract Documentation, then revised rates which take into account the percentage increased or reduced compaction effort per roller-pass, shall be agreed with the Contractor based on the same percentage increase or decrease.

The unit of measurement for the addition of water shall be the kilolitre of water applied as required.

The tendered rates for the addition of water to achieve the required compaction shall include full compensation for the supply, delivery and application of the water when required.

Item	Description	Unit
C5.1.7	Construction of a roadbed trial section	
C5.1.7.1	Non wetting-up collapsing soil trial section at in-situ moisture content using conventional rollers and/or HEIC	cubic metre (m ³)
C5.1.7.2	Non wetting-up collapsing soil trial section by excavating the soil to stockpile and then importing the soil from the stockpile to controlled compacted layers	cubic metre (m ³)
C5.1.7.3	Wetting-up collapsing soil trial section	cubic metre (m ³)
C5.1.7.4	Inactive and normal clay	cubic metre (m ³)
	(a) By material modification	
	(b) By lime modification	
	(c) By removal of material	
C5.1.7.5	Active clay	cubic metre (m ³)
	(a) Roadbed construction using lime	
	(b) Roadbed construction by removal of active clay	
C5.1.7.6	Roller-pass compaction.	cubic metre (m ³)

The unit of measurement for a trial section shall be the cubic metre of material processed during construction of the trial section according to the authorised dimensions as specified in the Contract Documentation measured along the centre line of the road. A total length of at least 150 m of trial section and no more than 200 m will be measured for payment as a trial section.

The authorised depth and width of the trial sections including item C5.1.7.1 (the depth of compaction) and item C5.1.7.3 (the depth of wetting-up) shall be representative of what will ultimately be constructed as per the Contract Documentation.

The tendered rates for item C5.1.7.4(a) shall include full compensation to mechanically modify the material as specified in Clause A5.4.7.2 with the type of material and ratios of material as specified in the Contract Documentation.

The tendered rates for item C5.1.7.4(c) shall include full compensation for excavating and loading from the road prism and roadbed the inactive/normal clay material. Haul shall be measured and paid for from the point of loading to the point of off-loading.

The tendered rates shall include full compensation for setting out the trial section, preparing and providing the programme of work for the specific trial section and preparing the existing roadbed surface where required.

The tendered rates shall include full compensation for the application of water, in the case of items C5.1.7.3, C5.1.7.4, C5.1.7.5 and C5.1.7.6, all laboratory testing and for the full documentation of the construction techniques to produce a trial section that is compliant with the requirements specified in the Contract Documentation.

The addition of lime for construction of the trial sections shall be measured and paid for under Section C5.4.

Item	Description	Unit
C5.1.8	Construction of the roadbed in collapsing soil	
C5.1.8.1	Non wetting-up collapsing soil roadbed construction at in-situ moisture content using conventional rollers	cubic metre (m ³)
C5.1.8.2	Non wetting-up collapsing soil roadbed construction at in-situ moisture content using HEIC	cubic metre (m ³)
C5.1.8.3	Non wetting-up collapsing soil roadbed construction by excavating the soil to stockpile and then importing from the stockpile to controlled compacted layers	cubic metre (m ³)
C5.1.8.4	Wetting-up collapsing soil roadbed construction	kilo litre (kl)
C5.1.8.5	Water for wetting-up collapsing soil roadbed construction	kilo-litre (kl)

The unit of measurement for items C5.1.8.1, C5.1.8.2, C5.1.8.3 and C5.1.8.4 shall be a cubic metre of collapsing soil material constructed according to the authorised dimensions in the Contract Documentation, measured in-situ prior to the commencement of any construction.

The tendered rates shall include full compensation for setting out the collapsing soil material sections, for preparing and providing the construction programme for the roadbed construction and preparing the existing roadbed surface where required.

The tendered rates shall include full compensation for construction of the roadbed treatment all in terms of the Contract Documentation and/or in terms of the relevant compliant trial section constructed as per item C5.1.7. The tendered rates shall include full compensation for all labour, construction plant including conventional rollers (C5.1.8.1) or HEIC (C5.1.8.2), equipment and incidentals required to carry out the construction of the roadbed in collapsing soil material as specified.

The unit of measurement for item C5.1.8.4 shall be a kilolitre of water used to wet-up the collapsing soil.

The tendered rates for item C5.1.8.4 shall include full compensation for the provision and application of water for the construction of item C5.1.8.3, applied as per the compliant trial section under item C5.1.7.3.

Item	Description	Unit
C5.1.9	Construction of roadbed comprising normal and inactive clay	
C5.1.9.1	By material modification	cubic metre (m ³)
C5.1.9.2	By lime modification	cubic metre (m ³)
C5.1.9.3	By removal of material	cubic metre (m ³)

The unit of measurement shall be a cubic metre of inactive clay material constructed according to the authorised dimensions in the Contract Documentation and down to a depth of 200 mm for both items C5.1.9.1 and C5.1.9.2.

The tendered rates shall include full compensation for setting out each inactive clay section and preparing the existing roadbed surface where required. The tendered rates for C5.1.9.1 shall also include for loading the material.

The tendered rates for items C5.1.9.1 and C5.1.9.2 shall also include full compensation for construction of the roadbed treatment of inactive clay by material modification or lime modification, respectively, as specified. The tendered rates for each item shall also include full compensation for all labour, construction plant, equipment and incidentals required to carry out the construction of the roadbed by material modification or lime modification as specified.

The hauling of compliant fill material shall be measured and paid for from the point of loading to the point of off-loading as per Section A1.7 of Chapter 1.

The production of the compliant material is measured and paid for under Sections C4.1 and/or C4.2 of Chapter 4.

The procurement and mixing of the lime is specified and measured in Section A4.4 of Chapter 4 and Section C5.4 respectively.

Item	Description	Unit
C5.1.10	Construction of roadbed comprising active clay	
C5.1.10.1	Roadbed construction using lime	cubic metre (m ³)
C5.1.10.2	Roadbed construction by removal of active clay	cubic metre (m ³)

The unit of measurement shall be a cubic metre of active clay material constructed according to the authorised dimensions in the Contract Documentation.

The depth of treatment for item C5.1.10.1 shall be 200 mm unless otherwise instructed in the Contract Documentation or by the Engineer. The depth of treatment for item C5.1.10.2 is the depth indicated in the Contract Documentation up to a limit of 750 mm unless instructed otherwise in the Contract Documentation or by the Engineer.

The procurement and mixing of the lime for item C5.1.10.1 is specified and measured in Section A4.4 of Chapter 4 and Section C5.4 respectively.

The tendered rates shall include full compensation for setting out each active clay section and preparing the existing roadbed surface as specified.

The tendered rates for item C5.1.10.1 shall also include full compensation for construction of the roadbed treatment of active clay using lime modification as specified.

The tendered rates for C5.1.10.2 shall also include for loading and off-loading the active clay. The hauling of the active clay material shall be measured and paid for from the point of loading to the point of off-loading as per Section A1.7 of Chapter 1.

The tendered rates for each item shall also include full compensation for all labour, construction plant, equipment and incidentals required to carry out the construction of the roadbed as specified.

Item	Description	Unit
C5.1.11	Construction of roadbed comprising a pioneer layer	cubic metre (m³)

The unit of measurement shall be a cubic metre of pioneer layer material constructed in the authorised areas specified in the Contract Documentation or as instructed by the Engineer.

The compacted volume of the pioneer layer of material shall be taken as equal to 70 % of the loose volume of material in the hauling vehicles.

The tendered rate for the construction of the roadbed treatment using a pioneer layer over water-logged or soft clayey ground as per the Contract Documentation shall include full compensation for all labour, construction plant, equipment and incidentals required to carry out the construction of the roadbed using a pioneer layer as specified.

The loading and hauling of compliant pioneer material for the roadbed construction is measured and paid for as specified in Section A1.7 of Chapter 1.

The production of the compliant pioneer material is measured and paid for under Sections C4.1 and/or C4.2 of Chapter 4.

Item	Description	Unit
C5.1.12	Excavation for benches	
C5.1.12.1	Excavation for benches	
(a)	Side-cut to fill in soft material	cubic metre (m ³)
(b)	Side-cut to spoil in soft material	cubic metre (m ³)
C5.1.12.2	Excavation for benches using labour enhancement	
(a)	Side-cut to fill	
(i)	Soft material	cubic metre (m ³)
(ii)	Intermediate material	cubic metre (m ³)
(b)	Side-cut to spoil	
(i)	Soft material	cubic metre (m ³)
(ii)	Intermediate material	cubic metre (m ³)

The unit of measurement shall be the cubic metre of material measured in its original position in cut and computed by the method of average end areas from levelled cross-sections taken as specified. The cross-sections shall be taken prior to excavating the cut for the benches.

Excavations shall be done using conventional construction and/or labour enhancement as specified and measured.

The tendered rates for excavating of benches under item C5.1.12.1 shall include full compensation for excavating from the road prism and roadbed in the class of excavation indicated. The rate shall also include full compensation for moving, by bull-dozer or excavating and loading the fill material a maximum of 1,0 km into its final location in the fill or for excavation, loading, off-loading and disposing of the spoil material at designated spoil sites up to a maximum of 1.0km, as instructed by the Engineer, including shaping and levelling-off any piles of spoil material.

The tendered rates for excavating of benches under item C5.1.12.2 using labour enhancement, shall include full compensation for excavating from the road prism and roadbed in the class of excavation indicated, loading the fill material, off-loading and disposing of the spoil material at designated spoil sites, as instructed by the Engineer, including shaping and levelling-off any piles of spoil material. The tendered rates shall include wheelbarrow transport over a haul distance of 100 m.

Hauling beyond 1,0 km when using conventional construction plant and 100 m using labour enhancement, shall be measured and paid for under Section C1.7 of Chapter 1.

Construction of the fill is measured and paid for under Section C5.2.

Construction of the cut, exposed benched area, shall be measured and paid under the appropriate item in Section C5.1.

For payment purposes a distinction shall be made between materials as classified above.

Item	Description	Unit
C5.1.13	Construction of a levelling layer	
C5.1.13.1	Over roadbed treatment in hard material compacted to 90 % MDD	cubic metre (m ³)
C5.1.13.2	Over a constructed pioneer layer compacted to 90 % MDD	cubic metre (m ³)

The unit of measurement shall be the cubic metre of material measured in its final position and computed by the method of average end areas from levelled cross-sections taken as specified. The cross-sections shall be taken prior to the importation of the levelling layer and after completion of the levelling layer.

When measurement by cross-sections is considered impractical the Contract Documentation may specify that the volume of the levelling layer can be computed as 70 % of the loose volume in the haul trucks.

The tendered rates shall include full compensation for the construction of the levelling layer of varying thickness, with an average thickness of 200 mm and shall also include for all labour, construction plant, equipment and incidentals required to carry out the construction of the roadbed using a levelling layer as specified as well as compaction to the specified MDD.

The production of the compliant levelling layer material, is measured and paid for under Sections C4.1 and/or C4.2 of Chapter 4.

Loading and hauling of the compliant material for the levelling layer is measured and paid for in Section C1.7 of Chapter 1 and is measured from the point of loading to the point of off-loading as per Section A1.7 of Chapter 1.

QUESTIONS?

2.4. Section 5.2 – Fill

5.2 FILL

CONTENTS

PART A: SPECIFICATIONS

- A5.2.1 SCOPE
- A5.2.2 DEFINITIONS
- A5.2.3 GENERAL
- A5.2.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS
- A5.2.5 MATERIALS
- A5.2.6 CONSTRUCTION EQUIPMENT
- A5.2.7 EXECUTION OF THE WORKS
- A5.2.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

A5.2 FILL

PART A: SPECIFICATIONS

A5.2.1 SCOPE

This Section covers the work requirements for off-loading and the subsequent processing of compliant fill material.

The work requirement for loading and hauling the fill material is specified in Section A1.7 of Chapter 1.

The fill material is produced as specified in the relevant Sections of Chapter 4.

A5.2.2 DEFINITIONS

The relevant definitions in the standard specifications are applicable. Additional definitions for this Section are included here.

Haul material - any construction material that is hauled between the point of loading, or the point of collection and the point of off-loading. Construction material may include all borrow, cut and reclaimed materials produced as specified in Sections A4.1, A4.2 and A4.3 of Chapter 4 and all spoil, and unsuitable material. Material obtained from commercial sources or from alternative sources, as specified in Sections A4.4 and A4.5 of Chapter 4, shall not be classified as haul material.

A5.2.3 GENERAL

A5.2.3.1 Fill dimensions and shape

The dimensions of fills shall be in accordance with the road design reflected in the typical cross-sections and other details contained in the Contract Documentation.

The Contract Documentation shall contain relevant details regarding the following:

- the required slope/batter of each fill,
- geometric layout details of each fill at interchanges and intersections,
- the proposed use of material for each fill. (Additional note: A Mass Haul Diagram may have to be prepared?)
- the method and classification of compaction for the fills as per Clause A5.2.3.4.
- any physical restrictions or material conditions that may affect the construction of the fill, and
- the proposed sequence of fill construction along the length of the project.

During compaction, the fill layer shall be maintained to the required shape and cross-section.

The compacted fill layers shall be adequately drained and shaped to prevent water from standing on the fill layers or scouring the completed work.

A5.2.3.2 Fill adjacent to existing fill

Where existing fills are widened, or where new fills are to be constructed adjacent to existing fills such as to construct an additional carriageway along with a median, the existing fill side slopes shall be benched in accordance with the details provided in the Contract Documentation.

A5.2.3.3 Fill layer thickness

The layer thickness used for the construction of the fills is dictated by the type and grading of the fill material and the compaction equipment being used. Fill layer thicknesses specified in the Contract Documentation are based on the expected material type and on the use of typical compaction equipment.

Fill layers shall be placed in successive layers at the same slopes and cross-fall as the final road surface. The construction of wedge-shaped fill layers shall be restricted to the bottom layers of high fills where this may be unavoidable due to changes in the road cross fall and super elevation or where the tapering out of the fill occurs. Benching shall be carried in terms of the specification in Clause A5.2.7.3 to avoid wedge-shaped fill layers. Where a new fill layer is constructed on an existing or already constructed fill and the new layer will be less than 100 mm in compacted thickness, the existing fill shall be scarified to such a depth as will give a compacted layer thickness of not less than 150 mm of the new plus scarified material together.

During the initial construction of fill layers or of a trial fill section, if so instructed by the Engineer, the Contractor shall confirm the construction layer thicknesses and the type of compaction equipment to be employed and shall then submit the method of compaction to the Engineer for review and acceptance.

The compacted fill thickness shall be as follows for the different types of compliant fill material used unless specified otherwise in the Contract Documentation or instructed by the Engineer after reviewing the Contractor's compaction process and equipment.

(Additional note: Material definitions below in Section 4.1 clause A4.1.2.)

a) Sand

Sand fill material may be compacted in layer thicknesses **not exceeding 400 mm subject to the construction of a compliant trial section**. The trial section shall be constructed as part of the fill, at no additional cost to the Employer other than the cost of the actual constructed fill.

b) Normal fill

Normal fill material shall be compacted in layers **not exceeding 200 mm** after compaction.

c) Coarse fill

Coarse fill shall be compacted in layers **not exceeding 500 mm** after compaction.

d) Rock fill

The maximum compacted thickness of a **rock fill layer shall not exceed 750 mm**.

(Additional note: The layer thicknesses of coarse fill and rock fill are maximum and depend on the compaction equipment used.)

A5.2.3.4 Fill compaction classification

The classification of material as hard material or intermediate material in the case of labour enhancement, to compensate the Contractor for the cost of excavation thereof, shall not be taken into consideration for any additional compensation in respect of the classification of the same material when used in the compacted fill.

The method of processing and compacting the fill material shall be classified as specified hereafter.

a) MDD compaction

Wherever a density requirement in respect of a fill layer is specified in the Contract Documentation in terms of a percentage of MDD, the Contractor may employ any type of compaction equipment to achieve such density over the full, as-specified, depth of the layer. The compaction equipment employed shall be adequate and suitable for the purpose and shall not create lamination layers or shear cracks.

The Contractor shall restrict the size of the compaction equipment being used, if necessary, in order to ensure that no part of the already completed works, any underlying structures, adjacent buildings or underground services are damaged during the compaction process.

(i) Sand fill

Sand fill material with properties as specified in Clause A4.1.5.4 of Chapter 4 shall be subject to a minimum percentage compaction of MDD. This sand shall be **compacted to 100 %** of MDD, unless specified otherwise in the Contract Documentation.

Notwithstanding this compaction criteria, the **compactability of the sand fill material shall be assessed and then confirmed by means of the construction of an appropriate trial section or trial sections**. The Contractor's selected compaction process shall form part of the submitted Management and Utilisation (M&U) plan.

(ii) Normal fill and coarse fill

Normal fill and coarse fill material shall both be subject to a minimum percentage compaction of MDD. The compaction density shall normally be either **90 % of MDD or 93 % of MDD** as specified in the Contract Documentation. **(Additional note: Coarse fill compaction by roller-pass may also be applicable, refer below.)**

(iii) Fill widening

Unless specified otherwise in the Contract Documentation the fill material placed in a fill widening shall be benched as specified in Clause A5.2.7.3 and compacted to **93 % MDD irrespective of the depth of the embankment fill**, to avoid or minimise differential settlement.

Where it is not possible to achieve 93 % MDD at the roadbed level, the Engineer shall instruct alternative roadbed compaction or treatment.

(iv) Roller-pass compaction

When the bottom layer of a fill is compacted **on top of soft or marshy ground, over a synthetic fibre membrane**, the compaction shall be carried out by roller-pass compaction in accordance with Section A5.1.

When the nature of the fill material is such that the degree of **compaction cannot be satisfactorily controlled by testing the compaction density, such as for a coarse fill or for a rock-fill**, the compaction shall be carried out by roller-pass compaction in accordance with Section A5.1.

The number of roller-passes, the combination of compaction equipment required and the fill layer thickness shall be confirmed by

means of the construction of a trial section in each case.

A5.2.3.5 Fill in restricted areas

Suitable equipment and acceptable methods shall be employed in restricted areas so that the required densities will be obtained throughout the thickness of any one fill layer. If necessary, the layers shall be placed in thicknesses which are less than the specified layer thickness to suit the type of compaction equipment being used in a restricted area.

Clauses A1.1.3.2 and A1.2.3.23 of Chapter 1 are applicable to all construction work in restricted areas.

A5.2.3.6 Contractor prepared plans for fills

The Contractor shall prepare and submit a Management and Utilisation (M&U) plan for every fill where the quantity of fill material exceeds 10 000 m³ or the length of fill exceeds 1,0 km.

To ensure that fill is constructed in a sustainable and sensitive manner, that environmental impacts are minimised, that fill layer material and haulage thereof is optimised and that costs are minimised, the M&U plan for the fill shall at least take cognizance of the following and provide detail of the following as appropriate:

- A method statement and programme for the construction of each fill
- A method statement for ensuring the material can be used directly to eliminate or minimise any temporary stockpiling;
- The sequence and processing of the fill directly from borrow, from cut or from stockpile;
- The survey methods to stake the toe of the fill embankments and control the side slopes and fill levels;
- A method statement of how the fill material will be protected from becoming too wet from whatever source of water;
- Details of any additional temporary drains that may be required along with the size, location and timing of the construction thereof, to protect the road prism from storm damage during construction;
- How oversize material will be dealt with;
- How work will be carried out in restricted areas;
- A method statement of how benching for the widening of fills or for the construction of fills located on a steep cross-fall, will be carried out;
- Measures to comply with the conditions of the statutory road environmental approval;
- Measures to comply with regulations and obligations in terms of Section A1.2 of Chapter 1 and the current Construction Regulations;
- The quality assurance detail for the applicable materials tests along with the frequency and quantity of such testing for each constructed section of each fill layer to ensure full compliance of the as-constructed fill in terms of compaction density and material quality, and
- Procedures for regular monitoring, auditing and reporting

M&U plans need to be submitted during the course of construction. The Contractor's construction programme shall set out by when each M&U plan will be submitted for review. The construction of a particular layer shall only commence once the Contractor's M-&U plan for that layer has been reviewed and accepted by the Engineer. The Engineer shall respond within one week after receiving an M&U plan.

A5.2.4 DESIGN BY THE CONTRACTOR/PERFORMANCE BASED SYSTEMS

Not required for this Section A5.2.

A5.2.5 MATERIALS

A5.2.5.1 Material specification

The material specifications for use in the construction of fills are given in Section A4.1 of Chapter 4 in the following clauses:

- Clause A 4.1.2 Definitions for Sand fill, Normal fill, Coarse fill and Rock fill material under sub-heading Fill layers
- Clause A4.1.5.4 Sand, normal and coarse fill material in the earthworks
- Clause A4.1.5.5 Rock fill material in the earthworks layers
- Clause A4.1.5.9 Sand in fill and pavement layers of sealed low volume roads
- Clause A4.1.5.13 Drainage layer material

Material excavated for the construction of infrastructure such as open drains, subsoil drains, culverts, bridge foundations and other structures, shall, if compliant and instructed by the Engineer, be used for the construction of fills.

A5.2.5.2 Use of fill material

The different types of fill material that can be used as fill material are defined in Clause A4.1.2 of Chapter 4. The specific use of each type of fill material is specified hereafter:

- Only normal fill material shall be used at a depth less than 150 mm below the top of the fill, unless specified otherwise.
- Only normal fill or coarse fill shall be used to construct a fill widening unless specified otherwise.
- Coarse fill material shall only be used up to a depth of 150 mm below the top of fill, unless specified otherwise.
- Rock fill material shall only be used up to a depth of 300 mm below the top of fill, unless specified otherwise.
- The fill material to be used in high fills as per Clause A5.2.7.9 shall be specified in the Contract Documentation.

A5.2.5.3 Unsuitable fill material

When the Contractor renders compliant fill material unsuitable for use due to inappropriate handling and/or processing methods, then such material shall be removed from the road and disposed of at a designated spoil site at no cost to the Employer. The replacement of the non-compliant fill material shall also be at no cost to the Employer.

Where there is a nett surplus of cut material for use as fill, the Contractor may be reimbursed for the removal to spoil of the now non-compliant material as if taken directly from the cut. A surplus of cut material for fill implies that the surplus has to be disposed of in any event. The Contractor shall not be reimbursed for any costs for the replacement of the material, irrespective of the source of the replacement material.

All unsuitable fill material, whether designated unsuitable in the Contract Documentation or rendered unsuitable by the Contractor, must be broken down sufficiently for convenient loading and transporting to the designated spoil area. Sufficient material shall be broken down to a maximum size of 500 mm with a view to effectively trimming the designated spoil areas.

A5.2.5.4 Wet fill material

The Contractor shall take measures to prevent fill material on the road becoming excessively wet as a result of rain, groundwater or storm run-off water. These measures shall form part of the Management and Utilisation (M&U) plan.

When these measures to keep the material dry and/or to dry it out have been taken and it remains too wet, the Engineer shall declare the material to be unsuitable. If the material declared unsuitable has already been placed on the road, the Engineer shall instruct that it be removed and replaced with alternative compliant material at no cost to the Employer.

A5.2.6 CONSTRUCTION EQUIPMENT

Construction equipment to carry out the construction of fill efficiently shall comply with the requirements of Clause A1.2.6 of Chapter 1.

A5.2.7 EXECUTION OF THE WORKS

A5.2.7.1 Compaction of fill material

Material used for the construction of a fill layer, from borrowpits or from cuttings, shall be prepared and used as set out in Clauses A4.1.7 and A4.2.7 of Chapter 4 respectively, during the excavation, placement and compaction thereof.

After fill material in borrow pits and cuttings has been broken down to the maximum size specified in Clauses A4.1.7 and A4.2.7 of Chapter 4 and then spread on the road, the oversize in excess of 5 % by volume shall be further broken down by means of suitable equipment such as a grid roller or a pad-foot roller.

In many cases breaking down oversize material by the normal compaction process may prove adequate, and no special effort should be necessary for breaking down the material, but, in the case of hard material, the engineer may require that the material be broken down by light grid-rolling. The degree to which the breaking down occurs shall then serve as the norm for what may be required with regard to alternative breaking down methods. For the purposes of these specifications light grid-rolling is defined as follows:

- The material shall be spread in a layer, the uncompacted thickness of which shall be approximately the average maximum fragment size, but with a minimum uncompacted thickness of 200 mm. It shall then be rolled by means of at least two complete roller-passes per 200 mm uncompacted layer thickness, by a grid roller with a mass of not less than 13,5 tons, travelling at a speed of at least 12 km/h whether towed or self-propelled. Should the uncompacted layer thickness be in excess of 200 mm, the roller-passes shall be increased pro rata.

Compensation for the light grid-rolling process to break down oversize material shall be regarded as being included in the pay item for providing, processing and compacting the material. Even when fill material is instructed to be compacted by means of a certain number of roller-passes, the two passes for breaking down the material will not be measured for payment.

Material that contains in excess of 5 % by volume of oversize material shall not be hauled to the road for use in sidewalks and in shoulder widenings.

Where any fill material contains less than 5 % by volume of oversize material, the oversize material shall be broken down by means of appropriate compaction equipment such as a grid roller or a pad-foot roller, or shall be bladed out of the layer or be removed from the layer by hand.

Compaction shall be carried out in a series of continuous operations covering the full width of the layer concerned. The length of any section of a layer being compacted shall normally not be less than 150 m nor more than what can be properly compacted during the available working period with the available equipment. The Contractor shall reduce the length of any fill layer compacted in any single operation if the specified compaction of such a layer is not being achieved.

The types and/or combination of compaction equipment to be used and the amount of rolling to be done shall be such as to ensure that specified densities or the required number of roller-passes are obtained without damage being done to the lower fill layers or underlying structures.

All holes, depressions or ruts shall be filled with compacted material and any lamination layers that may develop in the layer shall be removed or processed again to a minimum compacted depth of 150 mm.

A5.2.7.2 Fill drainage and protection

a) Road prism drainage

During fill construction, the road prism shall be kept well-drained and protected at all times by the Contractor.

The Contractor shall construct all permanent drains as soon as possible, as well as sufficient additional temporary drains as may be necessary to protect the road prism.

The provision of temporary drainage works shall include providing open channels, cut-off banks and the provision of and operation of temporary pumps and such other equipment as may be necessary for adequately protecting, draining and dewatering the works and the temporary works. This temporary provision will be in addition to any permanent drainage works specified and installed, and in addition to any temporary drainage works specifically paid for separately as in the case of diversions.

Throughout the construction of the works these permanent and temporary drainage provisions shall be maintained in good working order.

b) Fill layers drainage

Material spread over the road shall be spread with a cross slope at or greater than the slope of the final road surface and, **if not directly compacted, it shall receive at least one complete roller-pass compaction with a flat-wheel roller** in order to allow the water to run off rather than penetrate the uncompacted spread material. Precautions shall be taken to ensure that water does not dam up against material heaps, windrows, or any spread material or collect in low spots where it can form a pond and soak into the completed fill material.

Where fill material, despite proper precautionary measures, on account of its in-situ moisture content, is too wet to comply with the requirements with regard to moisture content during compaction, the Contractor shall dry out the material until it is suitable for compaction. Where wet in-situ conditions exist the Contractor shall, where possible, plan the construction programme so that material with a high natural moisture content will be excavated, placed and compacted during the dry season and not in the wet season.

The Contractor shall decide on the best method to dry wet material.

c) Fill protection

All completed fill layer work shall be protected and maintained until the following layer is constructed. Maintenance shall include immediate repairs to any damage or defects which may occur and shall be repeated as often as may be necessary to keep the layer continuously intact and in a good condition.

Ruts and potholes developing in the fills after completion shall be repaired, and damaged portions of the fills shall be reshaped and re-compacted at no cost to the Employer. Material shall not be spread on a constructed fill layer that is above its optimum compaction moisture content which can result in damage being caused to the layer during compaction of a subsequent layer.

All windrows shall be cut away or removed immediately after construction work to prevent the concentrated flow of water on completed fill layers. Cut-off berms or banks shall be constructed when and where required to prevent the erosion of fill slopes.

All cut and fill slopes shall be maintained by the Contractor until the road has been certified as being finally completed. All erosion and flood damage to slopes shall be promptly repaired.

Side drains discharging water from cuts and all other drains shall be so constructed as to avoid damage to the fills by erosion during the period before completion of the construction of the final drainage design.

A5.2.7.3 Benching for fill construction

Where the natural cross fall of the treated roadbed exceeds 1 vertical to 10 horizontal (1:10), the new fill shall be bonded to the roadbed by construction of benches.

The dimensions of the benches shall be as detailed in the Contract Documentation. The excavated material to create the benches shall be used directly for the construction of fill or taken to spoil as per the details in the Contract Documentation or as instructed by the Engineer.

The depth and width of benches cut into hard material may normally be smaller than those in soft material. Where benches are cut into hard material, the toe of the fill shall preferably also be constructed from rock material, and the benches shall be at least as deep as the largest rocks or boulders in the fill material. Benches in hard material shall be excavated to slope slightly inwards and the benched floor must have a broken and roughened or serrated surface so as to obtain a good bond between the surface of the bench and the fill material compacted on top of it.

The benches may be constructed in accord with Method A or Method B. The benching per Method A does not extend beyond the extremity of the road prism. The benching per Method B extends beyond the extremity of the road prism. All suitable and excess material obtained from the excavations for benching shall, in so far as is possible, be re-used for constructing the fills.

a) Method A

This method requires the cut of the first bench in the roadbed to be of adequate width to accommodate normal-width self-propelled construction equipment. The widths of successive benches shall be determined by the width of the fill at the elevation of the next bench.

The width of benches shall decrease gradually up to the stage where the fills in any case are wide enough for accommodating normal-width self-propelled construction equipment.

b) Method B

This method does not require the benching at the toe of the fill to be cut back adequately for accommodating normal-width construction equipment. The bench width shall be less than the normal-width for construction equipment and requires the fills then constructed to be so much wider (beyond the toe of the fill) as may be necessary for accommodating such equipment up to the height where the fill is sufficiently wide for construction equipment.

The Contract Documentation shall detail the width of the lowest bench to be cut beneath the new fill and the entire benching detail.

The position of the narrow first bench at the toe of the fill shall be accurately set out.

In the case of Method B benching construction, the Engineer may instruct that any excess width constructed adjacent to the toe of the fill should be removed to fill.

A5.2.7.4 Widening of fills

Where existing fills are to be widened, the fill slopes and the roadbed onto which the new fills are to be constructed shall be cleared and grubbed, as detailed in the Contract Documentation.

Where existing fills, or fills already constructed under the current project, are required to be widened or flattened, it shall be done **by way of bench construction in accord with Clause A5.2.7.3 and as per the details in the Contract Documentation.** The Contractor shall submit proposals for each fill widening or fill flattening less than 10 000 m³ not already included in the M&U plan, to the Engineer, for review before proceeding with such work.

Benches of not more than 500 mm vertical depth shall be cut into an existing fill. In the case of fills of less than 1.0 m height, and in the upper metre of any fill, the benches shall have a vertical depth equal to the actual individual fill layer thickness specified for constructing the widening. When the side slope of the existing fill contains any uncompacted material, the benches shall extend 'sideways' in a horizontal plane for a distance of at least 1m into the properly compacted portion of the original fill material or as per the details specified in the Contract Documentation.

All suitable material derived from cutting the benches shall be used in the construction of the widened section of the fill. Unsuitable material shall be removed to a designated spoil site as instructed by the Engineer or as per the Contract Documentation. Benches shall be compacted at the same time as the fill widening during the construction of the fill.

Where the existing fill consists of normal fill or coarse fill the widened section shall consist of normal fill or coarse fill respectively unless specified differently in the Contract Documentation.

A5.2.7.5 Rock fill embankment toe

Where required, rock fill embankments shall be protected by special embankment-toes, which shall be installed as detailed in the Contract Documentation or as instructed by the Engineer.

The toe shall be constructed simultaneously with the rest of the rock fill and shall consist of rock fill material varying in size between 150 mm and the maximum size of 500 mm. Where detailed in the Contract Documentation, a layer of synthetic-fibre filter material and a sand blanket shall be installed at the interface between the embankment rock fill and the rock fill protection toe. Care shall be taken not to damage or tear such material.

The toe shall be constructed and compacted as specified for rock fill. The outer part of the toe shall consist of the larger rocks properly bedded by means of smaller fragments so as to form a stable interlocking surface.

If placing with mechanical construction equipment does not achieve the required results, the equipment shall be supplemented with manual labour to select, to lever and place keystones in between the larger boulders until the correct placing is achieved and the rocks are firmly interlocked.

A5.2.7.6 Construction of rock fill

If the compacted layer is less than 500 mm thick then the largest dimension of any rock fragment shall not exceed the thickness of the compacted layer.

The material to be compacted shall be **off-loaded by the end-tipping method**. The material shall then be **spread** by bulldozer or other suitable equipment and shall be **so bulldozed and levelled as to properly mix the fine material with the rock**. The routes to be followed by hauling, spreading and compaction equipment shall be uniformly distributed over the entire width of the layer to be compacted. The material shall be **compacted during the spreading and compacting process using suitable rollers and finally compacted with vibratory rollers to achieve a good mechanical interlock of the rock and the best possible compaction and interlock of the finer material in the spaces between the rock**.

The type of vibratory roller used, the operating speed, the number of passes and the layer thicknesses are determined by means of the following formula:

$$(P_e \times n) / (h \times v) \geq 1500$$

P_e = total static and dynamic force per metre width generated by the vibratory roller at the operating frequency given by the manufacturer (kN/m)

n = number of passes required

h = thickness of the compacted layer in metres

v = roller speed in metres per second.

Operating frequencies shall be between 18 Hz and 30 Hz and P_e shall be at least 120 kN/m.

The rock fill shall contain sufficient fine material to fill the voids between the rock particles to form a dense layer with minimum voids between the rocks.

Rock fill that does not have sufficient fine material to fill the voids can be used in the works. After placing this rock fill, sandy material as specified in Clause A4.1.5.5 of Chapter 4 shall be spread uniformly over the surface using stiff brooms and the dry or watered sandy material shall then be rolled with a smooth drum vibratory roller and worked into the rock fill until no further settlement of the finer material occurs between the rocks and that all areas deficient in fines have been corrected.

The process shall continue until the voids in the rock fill have been adequately filled. All excess fines shall be removed from the surface of the rock fill. If the voids in the rock fill cannot be properly filled the thickness of the rock fill layers must be reduced so that it is possible to fill the voids to the bottom of each of the rock fill layers.

At the commencement of construction of a rock fill a trial section shall be constructed so that the rock fill construction process can be checked, amended if necessary and agreed to by the Engineer.

A5.2.7.7 Protection of structures

Proper precautionary measures shall be taken and, where necessary, additional temporary protection and/or support measures shall be provided to ensure that the method or procedure by which the fills are constructed will **not impose excessive loads on the structures, especially on incomplete structures**, as this may damage or overstress such structures.

A5.2.7.8 Fills up to 10 m high

Before the normal or coarse fill material is compacted, it shall first be thoroughly mixed by grader or other suitable equipment so as to obtain an even mix of the material and to spread the fine and coarse material evenly throughout the mixture. If necessary during the mixing process, water shall also be sprayed evenly over and mixed into the material to bring it to the correct uniform moisture content.

The moisture content to which the material shall be brought by adding water shall be sufficient to bring the material to the most favourable moisture content for the specific compaction equipment to be used and the percentage compaction required. If the moisture content of the material is **in excess of 2 %** above the optimum moisture content for the MDD, the Contractor shall still ensure the required compaction is obtained by carefully monitoring and adjusting the compaction technique or the material shall first be dried out to the required moisture content before compaction commences. **(Additional note: Be careful for this requirement. It is often interpreted that the compaction moisture content can exceed the optimum as long as the density is achieved. It is in fact required that the most favourable moisture content for the specific compaction equipment must be used. The "most favourable" moisture content for any roller 12 ton and larger is less than MDD optimum moisture content.)**

A5.2.7.9 Fills higher than 10 m (Additional note: Must be designed by an experienced geotechnical engineer.)

The construction of high fills shall require special techniques to prevent the development of excessive pore pressure and ensure the stability of such fills during and after construction.

These techniques may include, inter alia, the selection of better class material for use in the bottom layers of the fill, the construction of drainage blanket layer/s and the strict control of moisture content during compaction.

Permanent benches or steps shall be constructed in the batters or slopes of fills higher than 10 m for future access and maintenance purposes. These benches shall be sloped gently back towards the fill batter and catch water drains must be constructed on the benches to intercept storm water runoff. **The width and slope of these benches shall be as detailed in the Contract Documentation. (Additional note: Width sufficient to accommodate**

a concrete drain and safe travelling for construction and maintenance equipment.)

The material requirements for the construction of fills higher than 10 m are set out in Table A4.1.5-2 in Section A4.1 of Chapter 4. The specific requirements for the construction works shall be implemented as detailed in the Contract Documentation.

A5.2.7.10 Drainage layer(s) in fills

At the bottom of fills, and sometimes at intermediate levels, the construction of a drainage layer or a sand filter layer or other specified drainage layer may be required to facilitate the drainage of fills. The requirements for the installation of a drainage layer shall be specified in the Contract Documentation. The grading of the material used for the drainage layer shall be as per Table A4.1.5-13 of Chapter 4.

Sand filter blankets shall be constructed in accordance with the details in the Contract Documentation. The surface on which the sand filter blanket is to be constructed, shall be smooth and even and the sand shall be spread evenly to the required thickness and be given a one roller-pass compaction with a suitable roller. The final surface of the sand filter blanket shall be finished off true to line and level.

If the fill material consists of coarse material with a maximum particle size exceeding 75 mm the layers immediately below and above the filter blanket shall be constructed from selected soil or gravel with a maximum particle size of 50 mm.

A5.2.7.11 Drainage layer(s) in cuttings

Once the roadbed preparation through a cutting with a hard formation has been constructed in accordance with the details in the Contract Documentation, the initial layer on top of the completed roadbed shall be a drainage blanket layer where specified in the Contract Documentation.

The drainage blanket layer shall be constructed on top of the roadbed with material which conforms to the requirements for a drainage blanket layer as specified in Section A4.1 of Chapter 4 and shall merely be lightly compacted with an agreed number of roller-passes to smooth and level it.

The drainage blanket layer shall have a nominal placement thickness of 150 mm with a minimum compacted thickness of not less than 100 mm in any one place, and shall comply with the level tolerances for the equivalent fill or pavement layer. The average drainage layer thickness based on levels before and after placement of the drainage layer shall not exceed 200 mm.

The drainage blanket layer shall be protected from contamination by installing suitable geotextile layers below the blanket layer and then on top of the drainage layer ahead of the next layer of fill or of the pavement. The compacted thickness of the next layer of material constructed on top of the drainage layer shall have a maximum compacted thickness of 200 mm and only the upper 150 mm of the layer shall be processed and compacted. The density shall be as specified or the layer shall be compacted by approved roller-pass compaction all as instructed by the Engineer. This will ensure that neither the geotextile over the drainage layer or the drainage layer itself will be compromised.

A5.2.7.12 Fill in restricted areas

Clauses A1.1.3.2 and A1.2.3.23 of Chapter 1 are applicable to all construction work in restricted areas.

a) Additional requirements

In restricted areas the Engineer may permit the Contractor to spread, water and mix the fill material in a windrow next to the working area or at a nearby location from which it can be loaded and hauled to the working area. Care shall be taken not to damage any adjacent works and not to contaminate the mixed material with deleterious material. Where this method of mixing is impractical or impossible, the Contractor shall make use of concrete mixers or any other mixing equipment or acceptable method.

Irrespective of the layer concerned, the mixing shall ensure that a uniform mix will be obtained at all times. Areas where mixing of materials probably could be done in this manner is for the construction of a sidewalk, a shoulder widening or any other area identified in the M&U plan.

b) Construction of fills near structures

At structures such as bridges and large culverts, the construction of the fill and the backfilling immediately adjacent to the structure cannot be done simultaneously. The fills shall be so constructed that the longitudinal slope of the surface of the fill shall at all stages form a continuous plane sloping at a gradient not exceeding a 10 % incline towards the original ground level at the structure or the changing ground level at the structure as backfill progresses against the structure. Temporary drainage measures must be provided to ensure that rain water or storm water run-off, does not form ponds at the structures.

When the structure is completed, the remaining portion of the fill shall be completed including benching into the 10 % slope, simultaneously with the backfilling behind the structure.

The backfill behind and fill over the top of the structure, when applicable, shall be maintained at the same elevation as the benching of the adjoining fill.

A5.2.7.13 Finishing off slopes

a) General requirements

The Contractor shall not disturb the slopes of cuts and fills of an existing road prism unless such cuts or fills are required to be widened or flattened.

Where the new road has been widened temporarily to accommodate traffic and the widening is no longer required, it shall be trimmed back to the standard cross-section as per the Contract Documentation or as instructed by the Engineer. The surfacing shall be saw-cut or cut with a trimming wheel. This forms a neat reference line along the new shoulder breakpoint and the surplus material shall then be bladed off to the required slope, loaded and transported to a designated landfill site or other designated spoil area. The road surface shall not be damaged.

When so instructed by the Engineer, adjustment to the slopes shall be made to avoid damage being done to existing trees and to harmonise with existing landscape features. The transition to such adjusted slopes shall be gradual.

Clause A1.2.3.23 of Chapter 1 is applicable for slopes in restricted areas requiring to be finished.

b) Fill slopes

The side slopes of fills shall be finished (or shaped) as follows:

- The slopes shall be finished to a standard which is generally obtainable with proper care and workmanship in the type of material concerned. Care shall be taken not to undercut any side slopes which can cause sections to have a steeper slope than specified.
- Slopes at the junction of cuttings and fills shall be adjusted and evenly shaped so as to flow into one another or into the natural ground without a noticeable break that can be readily discerned from the road,

- The degree of finish required shall depend on the nature of the material used for the construction of the fill and hence of the fill slope but shall be as smooth as is consistent with the material involved and good workmanship.
- No individual boulders occurring in otherwise smaller sized material shall be allowed to project beyond the surface. All loose rocks, boulders and cobbles in excess of 75 mm shall be removed from the finished side slopes,
- In the case of **rock fill**, soft material shall be dumped over the sides of fills and worked into the gaps or voids between the rock on the surface of the fill slope.
- Slopes within soft material shall be finished to the natural angle of repose of the material or to a maximum slope of 1 vertical to 2 horizontal.
- The final surface of the side slopes shall have a slightly roughened surface that will be suitable for subsequent top soiling and grassing,
- Fill slopes shall be finished to neat lines with normal fill material. Any boulders or otherwise unsuitable material deposited on such slopes from overspill or whatever other reason shall be removed and any damage caused shall be reinstated, including the re-establishment of vegetation where applicable.
- Batters / fill slopes shall be finished to within a tolerance of 100 mm above to 100 mm below the specified side slope line. All undulations shall follow a smooth line.
- The removal of over-built material on fill slopes shall be completed before any pavement layer work is commenced with, that is before the pavement layer profile pegs are erected.
- The **final finishing of fill side slopes**, profiling and cleaning shall be completed after the completion of the construction of all the pavement layers but **before commencing with the placing of any surfacing**.
- The tops (shoulder break point) and bottoms (edge of road prism) of all side slopes shall be rounded. The extent of this rounding shall be 600 mm, or as indicated on the drawings or as instructed by the Engineer,
- In preparation for grassing the side slopes designated for grassing shall receive a 75 mm to 150 mm thick topsoil layer as per Chapter 11 of the specifications and shall be vegetated.

c) Median slopes and interchange areas

Median slopes and the areas between interchange ramps shall be finished to the same level tolerances as specified in Clause A5.2.8.3 for the top layers of fills. This tolerance shall apply to the top layer of these slopes and areas.

For the sides of fills steeper than 1 in 4, the requirements of Clause A5.2.7.13b) shall apply.

d) Cutting slopes

The finishing of cutting slopes is specified in Clause A4.2.7.1n)

A5.2.7.14 Spoil of surplus and redundant fill material

Any surplus fill material such as waste or oversize material bladed off the road, shall be disposed of as spoil material by the Contractor as instructed by the Engineer at a designated spoil site or at a landfill site. Spoil material shall not require compaction but shall be spread, shaped and given a smooth surface as may normally be obtained by using a bulldozer.

Excess fill material placed by the Contractor outside the specified lines and levels shall be removed during the trimming operation at no cost to the Employer and it will not be measured for payment as cut to spoil.

A5.2.8 WORKMANSHIP

A5.2.8.1 Inspection of the works

The Engineer shall do routine inspections and conduct routine tests to determine whether the quality of material and workmanship provided, complies with the requirements of the Contract Documentation.

The Engineer shall do specific inspections of completed layers prior to the next layer being imported and specifically to determine whether the layer is still intact and after a rainfall to determine whether the layer has become saturated due to poor provision for temporary drainage.

A5.2.8.2 Material quality and compaction requirements

The quality of fill materials shall comply with the requirements of Chapter 4 prior to the material being transported to the site.

The compaction of fill materials shall comply with the requirements specified in Clause A5.2.3.4 and summarised in Table A5.2.8-1.

Table A5.2.8-1: Summary of material requirements and layer thickness

Material description or use	Type of compaction	Individual layer thickness (t)	Compaction (% of MDD)
Sand Fill	MDD	$t < 400 \text{ mm}$	100 % as per Clause A5.2.3.4
Normal fill	MDD	$t < 200 \text{ mm}$	90 % or 93 % as per the Contract documentation
Coarse fill	MDD	$t < 500 \text{ mm}$	90 % or 93 % as per the Contract Documentation
Rock fill	Formula	$T < 750 \text{ mm}$	Formula as per Clause A5.2.7.6
Fill widening (only normal or coarse fill material to be used)	MDD	$200 \text{ mm} < t < 500 \text{ mm}$	93 % for entire height of fill
Fill over soft or marshy terrain using compliant fill material as instructed by the Engineer	Roller-pass	Determine by trial section	Determine number of roller-passes by trial section

The in-situ measured density of the fill layer being tested complies with the compaction requirements when the results of at least 75 % of the in-situ density tests of any lot, located as per the Contract Documentation, are equal to or exceed the specified value and **no single density is more than 3 percentage points below the specified value. (Additional note: Reduced from the COLTO 5 %)**

Fill materials treated by providing roller-pass compaction shall be compliant when the agreed number of passes as determined during the construction of a trial section, or as specified in the Contract Documentation, or as instructed by the Engineer have been observed and recorded as being the correct quantity.

A5.2.8.3 Construction tolerances

The work specified in this Section shall be constructed to the following dimensional tolerances.

a) Levels

The level tolerances shall be as follows for fill, but shall **apply only to the top layer of the fill:**

$$H_{90} = \pm 25 \text{ mm}$$

$$H_{\text{max}} = \pm 35 \text{ mm}$$

b) Width

(i) Normal fill and coarse fill

The horizontal measurement taken from the centre line of the road to the side of the fill, shall nowhere be 125 mm less or 250 mm more than the specified dimension when measured at any level.

(ii) Rock fill

The horizontal measurement taken from the centre line of the road to the side of the fill, shall nowhere be 250 mm less or 1 000 mm more than the specified dimension when measured at any elevation.

c) Fill batters or slopes

The construction tolerances specified in Clause A5.2.7.13b) shall be complied with.

C5.2 FILL

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the constructional plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Items that will not be measured separately

The following required activities will not be measured or paid for separately and the Contractor shall include the cost thereof in other items as deemed appropriate:

1. Drainage and protection of the works from all damage that may occur for any reason until the Employer has taken over the works.
2. Protection and repair as required, until the Employer has taken over the works, of all existing and new roadside furniture, of all existing and new drainage structures and of all existing and new infrastructure. Any other items adjacent to, over or under the road that could be damaged by the Contractor's vehicles, equipment, or by public traffic being accommodated on or alongside the works, during the construction of the works.
3. Repair of any damage to the fill and services that may occur for any reason before, during or after the construction of the roadbed up until the Employer has taken over the works.
4. Provision of material in excess of the compacted volume of the layers calculated using the layer dimensions given in the Contract Documentation for whatever reason including additional material required for the correct placing, mixing, levelling and compaction of the layers.
5. Removal of all excess material required for the correct mixing and working of the layers and left in windrow or on the sides of the road.
6. No additional payment will be made for keeping dry or for drying out the fill material. The cost of such work shall be included in the tender rates for the various items of work for which the material is to be used, unless provision for additional compensation of this nature has been made in the Contract Documentation.
7. Where the material contains more than 5 % oversize material breaking down the oversize material as per Clause A5.2.7.1 using two roller-pass grid rolling.
8. Loading of the fill material during the excavation operation when the material is taken directly to the point of use.
9. Loading and hauling of commercial fill material identified by the Employer or by the Contractor.
10. Loading and hauling of alternative fill material identified by the Contractor.

(iii) Items to be measured and paid for using items specified elsewhere in the specifications

For activities in Table C5.2-1 payment items specified in other Chapters of the specification, where they relate to work under this Section, will be listed in the Pricing Schedule.

Table C5.2-1: Payment items from other Chapters or Sections

Activity	Section 5.2 reference	Section item reference
Drainage	A5.2.7.2	Section C3.1 of Chapter 3 – All applicable items
Hard material	A5.2.7.3	Section C12.10 of Chapter 12 – All applicable items
Ground improvement (Specialist roadbed treatment)	A5.2.7.4	Section C12.3 of Chapter 12 – All applicable items
Clearing and grubbing and removal of large trees	A5.2.7.4	Section C1.6 of Chapter 1 – All applicable items
Synthetic fibre filter	A5.2.7.5	Section C12.11 of Chapter 12 – All applicable items
Topsoiling	A5.2.7.13.2	Section C11.8 of Chapter 11 – All applicable items
Additional testing	A5.2.1	Section C4.1 of Chapter 4 – All applicable items
Loading and hauling material	All A5.2 references	Section C1.7 of Chapter 1 – All applicable items

(iv) Determining the quantities

The Contractor and the Engineer shall determine quantities for the work specified in this Section C5.2 all as specified in Section C5.1 under clause C5.1(vi) Determining the quantities.

(v) Roadbed subsidence

Where it has been determined that the roadbed is subsiding as fills are being constructed, and after the roadbed work has been completed and cross-sections have been agreed on, the Contractor may request that the fill quantities shall be adjusted accordingly. **(Additional note: Levels are compared to the roadbed cross-sections taken in Section 5.1.** Such requests shall be lodged without delay as soon as the Contractor becomes aware of any possible subsidence and the Contractor shall submit the required supporting evidence to the Engineer. Where the Engineer is satisfied that significant subsidence is occurring, the Engineer and the Contractor shall decide as to how the extent of the subsidence is to be determined. Any adjustments for subsidence shall be made only where the average subsidence exceeds 50 mm.

The measurement and payment for the planned subsidence of a roadbed by means of pre-loading is specified in Chapter 12.

(vi) **Work in restricted areas**

Clause C1.1.3.2 of Chapter 1 shall be complied with.

(vii) **Payment items specifically for this Section of the specifications**

Item	Description	Unit
C5.2.1	Compiling and implementing M&U plans	
C5.2.1.1	For fills more than 10 000 m ³ (list all fills separately)	number (No)
C5.2.1.2	For fills 1,0 km in length when less than 10 000 m ³ (list all fills separately)	number (No)

The unit of measurement shall be the number of compiled M&U plans for the construction of the fills.

The tendered rates shall include full compensation for gathering all information and compiling the plans and for ensuring the implementation of the plans during the construction of each fill for which an M&U plan has been compiled.

Item	Description	Unit
C5.2.2	Fill construction	
C5.2.2.1	Normal fill material in compacted layer thicknesses of 200 mm and less:	
(a)	Compacted to 90 % of MDD	cubic metre (m ³)
(b)	Compacted to 93 % of MDD	cubic metre (m ³)
(c)	Roller-pass compaction	square metre (m ²)
C5.2.2.2	Coarse fill material in compacted layer thicknesses exceeding 200 mm: but less than 500 mm	
(a)	Compacted to 90 % of MDD	cubic metre (m ³)
(b)	Compacted to 93 % of MDD	cubic metre (m ³)
(c)	Roller-pass compaction	square metre (m ²)
C5.2.2.3	Sand fill material in compacted layer thicknesses of 400 mm and less, compacted to 100 % of MDD	cubic metre (m ³)
C5.2.2.4	Rock fill material all as per Clause A5.2.7.6	cubic metre (m ³)
C5.2.2.5	Rock fill embankment toe	cubic metre (m ³)
C5.2.2.6	Sand filter layer	cubic metre (m ³)
C5.2.2.7	Drainage blanket layer	cubic metre (m ³)

The unit of measurement except for items C5.2.2.1(c) and C5.2.2.2(d) shall be the cubic metre of material measured in the compacted fill. The measurement of fill shall distinguish between the different types of fill and methods of processing and compacting.

The unit of measurement for items C5.2.2.1(c) and C5.2.2.2(d) shall be the square metre of roadbed compacted in accordance with the specification for roller-pass compaction.

The quantity measured for items C5.2.2.1(c) and C5.2.2.2(d) shall be in accordance with the authorised dimensions of the area to receive roller-pass compaction as specified in Clause A5.1.7.3.

The quantity measured for items C5.2.2.1, C5.2.2.2, C5.2.2.3 and C5.2.2.4 except for items C5.2.2.1(c) and C5.2.2.2(d) shall be computed by the method of average end areas from levelled cross-sections. The cross sections shall be prepared from the ground line after completion of clearing and grubbing, after the removal of topsoil and after the completion of any roadbed treatment, but immediately prior to the construction of the fill. The final specified or authorised fill cross-sections in the Contract Documentation shall be superimposed thereon at 20 m intervals along the centre line of the road. All measurement shall be neat, and that part of the fill placed in excess of the authorised cross-sections, shall not be paid for, irrespective of the tolerances in workmanship allowed under the contract.

Where the roadbed has subsided under the fills, the fill quantities shall be adjusted to make allowance for such subsidence, as set out in Clause C5.2 (v).

The quantity measured for items C5.2.2.5, C5.2.2.6 and C5.2.2.7 shall be calculated from the authorised dimensions.

The tendered rates for all items shall include full compensation for preparing, processing, shaping, watering, mixing, and compacting the materials to the densities or in the manner specified. The tendered rates shall also include for breaking down or removing and disposing of any oversize material up to 5 % of the compacted volume from the road after processing, including loading and hauling the material to designated spoil sites. The limit of 5 % shall apply to individual layers and not to all the layers together.

Loading of the fill material shall only be measured when the material is taken from stockpile, when approved by the Engineer. The **haul** of the fill material shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

The tendered rates for material excavated for the construction of other infrastructure as per A5.2.5.1 and used for the construction of fills, shall also include for loading and off-loading the material. This is irrespective of any payment made for the excavation of such material. Payment shall be made under the appropriate item in C5.2.2.

Item	Description	Unit
C5.2.3	Side-cut to fill compacted to 93 % of MDD in compacted layer thicknesses of 200 mm and less	cubic metre (m³)

The unit of measurement shall be the cubic metre of material measured in the compacted fill.

This item shall apply to fill constructed with material bladed directly from cut to fill including material cut from the side slope of existing fills, pavement layers and from benches, using construction equipment such as a grader or bulldozer without having to load and haul the material to its point of use. The quantity of material shall be computed from the cross-sections as described for items C5.2.2 and/or the authorised dimensions of side-cuts or benches to be cut into the side slope of existing fills, superimposed thereon.

The tendered rate shall include full compensation for side-cutting the material by bull-dozing it side-ways, or by another appropriate construction method, to fill, placing the material along with the simultaneous cutting of benches to the shape and dimensions specified followed by the compaction of the material.

The tendered rate shall also include full compensation for preparing, placing the material, processing, shaping, watering, mixing, and compacting the material to the densities or in the manner specified herein. **(Additional note: The rate is for excavation, moving of material and compaction.)**

Item	Description	Unit
C5.2.4	Correcting rock fills that are deficient in fine material, extra over C5.2.2.4	cubic metre (m³)

The unit of measurement shall be the cubic metre of corrected rock fill.

The tendered rate shall include full compensation for procuring and furnishing approved material that passes through the 5.0 mm sieve, including all transport, for loading and off-loading, for placing and spreading, watering and rolling, for removing all excess fines from the surface of the rock fill, and for all other incidentals necessary for completing the work as specified.

Item	Description	Unit
C5.2.5	Fill in sidewalk	
C5.2.5.1	Fill material in sidewalk compacted to 93 % of MDD	cubic metre (m ³)
C5.2.5.2	Fill material in sidewalk compacted to 93 % of MDD using labour enhanced methods of construction and light hand equipment.	cubic metre (m ³)

The unit of measurement shall be the cubic metre of material measured in the compacted fill as calculated from the authorised dimensions of the sidewalk.

The tendered rates shall include full compensation for preparing, processing, shaping, watering, mixing, and compacting the material to the specified density or in the manner specified in the Contract Documentation irrespective of the source of the material. The tendered rates shall also include full compensation for building up or reinstating the fill in the sidewalk.

The tendered rates shall also include for breaking down or removing and disposing of any oversize material from the road after processing.

A distinction shall be made between construction using conventional construction methods and labour enhancement methods.

Loading of the fill material shall only be measured when the material is taken from stockpile, when approved by the Engineer. The haul of the fill material shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

Item	Description	Unit
C5.2.6	Fill material in shoulder widening	
C5.2.6.1	Fill material in shoulder widening compacted to 93 % of MDD	cubic metre (m ³)
C5.2.6.2	Fill material in shoulder widening compacted to 93 % of MDD using labour enhancement and light hand equipment.	cubic metre (m ³)

The unit of measurement shall be the cubic metre of material measured in the compacted fill as calculated from the authorised dimensions.

The tendered rates shall include full compensation for preparing, processing, shaping, watering, mixing, and compacting the materials to the densities or in the manner specified herein irrespective of the source of the material.

Loading of the fill material shall only be measured when the material is taken from stockpile, when approved by the Engineer. The haul of the fill material shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

The tendered rates shall also include for breaking down or removing and disposing of any oversize material from the road after processing.

A distinction shall be made between construction using conventional construction methods and labour enhancement methods.

Item	Description	Unit
C5.2.7	Construction of a trial section	
C5.2.7.1	Normal fill	cubic metre (m ³)
C5.2.7.2	Sand fill	cubic metre (m ³)
C5.2.7.3	Rock fill	cubic metre (m ³)
C5.2.7.4	Coarse fill	cubic metre (m ³)
C5.2.7.5	Roller-pass compaction	cubic metre (m ³)

The unit of measurement for a trial section shall be the cubic metre of material processed during construction of the trial section according to the authorised dimensions as specified in the Contract Documentation measured along the centre line of the road. A total length of at least 150 m of trial section and no more than 200 m will be measured for payment as a trial section. The authorised depth and width of the trial sections shall be representative of what will ultimately be constructed as per the Contract Documentation.

The tendered rates shall include full compensation for setting out the trial section, preparing and providing the plan for the specific trial section and preparing the existing road surface where required.

The tendered rates shall also include full compensation for the application of water, all laboratory testing and for the full documentation of the rolling techniques and combination of rollers all as specified.

Item	Description	Unit
C5.2.8	Breaking down oversize fill material on the road	
C5.3.5.1	By normal grid rolling as per clause A5.3.7.3b) (i) to (vii)	square metre-pass (m ² -pass)
C5.3.5.2	By tamping roller	square metre-pass (m ² -pass)
C5.3.5.3	By pad foot vibratory roller	square metre-pass (m ² -pass)
C5.3.5.4	By vibratory roller	square metre-pass (m ² -pass)

The unit of measurement shall be the square metre-pass calculated by multiplying the layer surface area covered by the agreed number of roller-passes used to break down the material satisfactorily.

The tendered rates for each square metre-pass instructed by the Engineer shall include full compensation for all supervision, labour, equipment, fuel, materials, work and incidentals necessary for completing the work. The same rates shall be applicable should there be a reduction in the number of roller-passes for a specific type of roller.

The tendered rates shall include full compensation for supplying the roller and removing the roller after completion of the breaking down process.

The items shall differentiate between the different types of rollers used.

Item	Description	Unit
C5.2.9	Removal of oversize material	cubic metre (m³)

The unit of measurement shall be the cubic metre of oversize material which cannot be broken down on the road and is removed for re-crushing or removed to spoil as instructed by the Engineer in excess of the 5 % of the compacted layer volume of oversize material included in the rates tendered for item C5.2.2.

The volume measured for payment shall be taken as 70 % of the loose volume in excess of 5 % of the measured volume of the layer as measured in the haul vehicles.

The tendered rate shall include full compensation for removing the oversize material from the fill layer, loading it into the hauling vehicles and off-loading it at the agreed point of disposal.

The haul of the oversize material in excess of 5 % by volume per layer shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

Item	Description	Unit
C5.2.10	Finishing off rock fill slopes Additional note: New item.)	
C5.2.8.1	Finishing off rock fill slopes with soft material	cubic metre (m ³)
C5.2.8.2	Finishing off rock fill slopes with soft material using labour enhancement and light, hand equipment.	cubic metre (m ³)

The unit of measurement shall be the cubic metre.

The volume shall be measured as 70 % of the loose volume measured in the trucks.

The soft material instructed by the Engineer to be dumped over the sides of rock fills for finishing will be measured and paid for as material in addition to the net specified dimensions of the road prism as indicated on the road cross-sections.

The tendered rates for finishing cut or fill slopes, medians and interchange areas shall include full compensation for all labour, equipment, materials and other incidentals and work required for finishing as specified, including the loading, transporting and disposal of any material brought down during the finishing operations.

Loading of the fill material shall only be measured when the material is taken from stockpile, when approved by the Engineer. The haul of the fill material shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

A distinction shall be made between construction using conventional construction methods and labour enhancement.

Item	Description	Unit
C5.2.11	Finishing-off fill slopes, medians and interchange areas	
C5.2.9.1	Fill slopes	square metre (m ²)
C5.2.9.2	Medians and interchange areas	square metre (m ²)

The unit of measurement shall be the square metre of cut or fill slopes or medians and interchange areas finished off as specified.

The areas shall be measured from topographical surveys measured along the slopes. It shall be the sloping area between the shoulder breakpoint and the toe of the fill in the case of fill slopes. The medians shall include the full width of the median between the inner edges of the shoulders. The extent of median areas which are to be finished off shall be determined in accordance with the drawings.

Areas, except fill slopes, required to be lined with cast in place or precast concrete linings, kerbing, channelling or chutes, as specified, shall not be measured and paid for under item C5.2.9. All fill slopes and channel bottoms of open drains resulting from open-drain excavations as defined in Chapter 3, as well as the floors and sides of existing open drains that are trimmed during the clearing and shaping of existing open drains as defined in Chapter 3, shall not be measured and paid for under item C5.2.9.

The tendered rates for finishing the fill slopes, medians and interchange areas shall include full compensation for all labour, equipment, materials and other incidentals and work required for finishing as specified, including the loading, transporting and disposal of any material arising or brought down during the finishing operations.

QUESTIONS?

BREAK!

2.5. Section 5.3 – Road pavement layers

5.3 ROAD PAVEMENT LAYERS

CONTENTS

PART A: SPECIFICATIONS

- A5.3.1 SCOPE
- A5.3.2 DEFINITIONS
- A5.3.3 GENERAL
- A5.3.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS
- A5.3.5 MATERIALS
- A5.3.6 CONSTRUCTION EQUIPMENT
- A5.3.7 EXECUTION OF THE WORKS
- A5.3.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

A5.3 ROAD PAVEMENT LAYERS

PART A: SPECIFICATIONS

A5.3.1 SCOPE

This Section covers the work requirements for loading at the point of supply, the hauling and off-loading at the point of use, the spreading, mixing, watering and levelling and the compaction and finishing of pavement layer material required for the construction of the road pavement layers. (Additional note: This is for the construction of all new pavement layers, whether for new road construction, in rehabilitation and in road widenings.)

This Section also covers the work requirements for the loading of pavement layer material at the point of supply, the haulage to a central mixing plant to add and mix water and stabilising agent with the pavement material, hauling the mixed material to a paver at the point of use and then the construction of the pavement layer by paving, compacting and finishing the layer. This operation is known as plant-mixed, paver-laid (PMPL) pavement layer construction.

Material for the road pavement layers is produced as specified in the relevant Sections of Chapter 4.

The addition and mixing of stabilising agents either as an integral part of the PMPL process or for some of the conventionally placed road pavement layers that require treatment and/or stabilisation is specified in Section A5.4.

The reconstruction of existing road pavement layers is specified in Section A5.5.

A5.3.2 DEFINITIONS

The relevant definitions elsewhere in the standard specification are applicable. Additional definitions for this Section are included here.

Single-operation - a single-operation is the amount of work that can normally be carried out during the course of a single work shift using the applicable construction equipment.

A5.3.3 GENERAL

A5.3.3.1 Sources of material

The sourcing of material shall take place as specified in Chapter 4.

Material shall be obtained from approved sources such as borrow areas, cuts, stockpiles or reclaimed road materials from existing road pavement layers. Reclaimed road material shall be processed as specified in Section A4.3 of Chapter 4 to produce a material compliant with the material properties specified in Chapter 4 for the particular intended use of the material, as specified in the Contract Documentation.

Material may also be obtained from compliant commercial and alternative material sources as detailed in the Contract Documentation.

Crushed stone material shall be obtained from approved sources such as quarries, commercial sources and approved cuttings.

A5.3.3.2 Use of material

The Contract Documentation shall detail the proposed layers for which the different materials are suitable, including the proposed use of commercial materials and alternative materials.

Notwithstanding the proposed use of the various sources of materials given in the contract document the Contractor shall ensure that all material used for the pavement layers complies with the relevant material quality as specified in Chapter 4.

A5.3.3.3 Requirements prior to the construction of any pavement layer

The first pavement layer shall not be constructed until the following construction work has been completed:

- Construction of the fill must be completed;
- Construction of the cut must be completed;
- Construction of the roadbed through a cutting in soft or hard material, must be completed;
- All over-built material on fill slopes must be removed. (Additional note: This requirement can be waived where the road is constructed wider to ensure adequate compaction of a crushed stone base.

The finishing of cutting slopes shall be completed prior to the construction of a subbase layer.

Before any material for a pavement layer is off-loaded onto the road for the subsequent construction of that pavement layer, the Contractor shall obtain approval of the underlying layer from the Engineer. Immediately prior to off-loading any pavement material onto the underlying layer the Contractor shall recheck the underlying layer to establish whether there is any localised damage or localised defects in the underlying layer, and if so, these shall first be rectified. Wet spots in the underlying layer are dealt with as specified in Clause A5.3.3.8.

A pavement layer shall only be constructed once the underlying layer meets all the specified requirements and has been approved.

In a new cutting, or in a completed box cut, the underlying floor layer needs to be processed and constructed as roadbed preparation. The specific roadbed preparation shall be as specified in the Contract Documentation or as instructed by the Engineer and shall take place as specified in Section 5.1. This roadbed preparation shall be constructed before the construction of the first pavement layer takes place on the constructed and approved roadbed preparation.

Where the in-situ material properties prove to be compliant with those for the first selected layer, the Contract Documentation or the Engineer may specify that the in-situ material shall be processed and constructed as per the requirements for a selected layer without any prior roadbed preparation being required. (Additional note: The material quality and density in the material depth must be investigated for compliance.)

A5.3.3.4 Compaction of pavement layer material

All material used for the construction of pavement layers shall be mixed with water to the required compaction moisture content prior to being processed and compacted to the specified thickness, level and density. The material shall be compliant with the material requirements for each specific layer. (Additional notes: 1. Contractor to determine compaction moisture content. Engineer never to specify moisture content. 2. Always work on dry side of MDD optimum)

Compaction shall be carried out in a series of continuous processing and compacting operations covering the full width of the layer concerned. The length of any section of a layer being compacted shall not be more than what can be properly compacted with the available equipment in a single-operation or shorter period when specified in the Contract Documentation.

The Contractor shall reduce the length of any layer compacted in any single-operation, and/or change the compaction process and/or change the number of, or type of, equipment being used, if the specified thickness, level or density of the layer is not being achieved.

The type of compaction equipment used and the amount of rolling done shall be such as to ensure that the specified density, or the specified number of roller-passes, is obtained without damage being done to any of the underlying layers due to breakdown or settlement of the underlying layer.

The compacted layer shall be completed to the required density, thickness, levels, shape and cross-section specified in the Contract Documentation and within the tolerances specified in this Section. All oversize material, lamination layers and any excess material shall be removed from the compacted surface before any further pavement layers or surfacing is carried out.

A5.3.3.5 Existing or newly constructed infrastructure

During the construction of pavement layers, all existing or newly constructed drainage infrastructure such as concrete edging, kerbing and channelling, sidewalks, lined drains, manhole covers, kerb inlets and gratings shall not be displaced or damaged.

Furthermore, no damage shall be caused to any existing or newly constructed structures such as culverts, bridges and buildings or any roadside furniture such as road signs, guardrails, streetlights, fencing, service pipes and cables during the construction of pavement layers.

Where necessary small hand-operated compaction equipment shall be used to ensure that the specified compaction is achieved immediately adjacent to drainage infrastructure, structures and roadside furniture.

Any items damaged during construction shall be replaced or repaired immediately by the Contractor, at no cost to the Employer.

A5.3.3.6 Tie-ins at existing bituminous surfaces

At junctions with existing bituminous surfaces, the existing surfacing and layer work near the tie-in shall be cut back in a neat, straight line so as to ensure that the compacted thickness of the new base layer all the way up to the tie-in point, is not less than 150 mm.

A5.3.3.7 Joints between pavement layers

a) Location of joints

Pavement construction joints, or overnight stops, in each successive layer of the pavement, shall be staggered and never be directly above the construction joint in the underlying layer.

The final manifestation of a longitudinal joint in the asphalt surfacing shall coincide with a road marking line (lane or shoulder) or with the middle of a traffic lane as detailed in the Contract Documentation. Under no circumstances shall the longitudinal joint in the pavement base layer or in the asphalt layer be located along a traffic wheel path.

Longitudinally, the joint between new and existing asphalt surfacing layers shall be off-set at least 100 mm from the longitudinal construction joint between the pavement base layers.

Transversely, the joint between new and existing asphalt surfacing layers shall be off-set at least 500 mm from the transverse construction joint between the pavement base layers.

b) Longitudinal joints

A longitudinal joint shall be formed between existing pavement layers that are to remain intact and the adjacent widened pavement layers or the adjacent pavement layers to be reconstructed.

The construction of longitudinal joints shall commence with a saw-cut through the existing surfacing and through each bound layer (G1 and/or G2), any stabilised layer to the depth as detailed in the Contract Documentation. After each layer has been saw-cut, the layer material on the widening side of the saw-cut or on the reconstruction side of the saw-cut, shall be removed to sufficiently expose the layer below so that the next saw-cut through the bound or stabilised layer beneath can be made. The position of the next saw-cut shall be at least 150 mm away from the first saw-cut, and further away from the pavement layers that are to remain intact. This procedure shall be repeated until all the layers to be removed have been saw-cut.

Ultimately the longitudinal joint shall comprise a series of steps that are 150 mm wide and vertically the depth of each layer unless specified otherwise in the Contract Documentation. The saw-cut prevents adjacent intact layers from being damaged during the material processing or reconstruction and prevents a longitudinal crack developing immediately above the widening or reprocessing location.

c) Transverse joints

A transverse joint is required between pavement layers when the road pavement length is extended or between two new sections of pavement layer construction. A transverse joint so formed shall be perpendicular to the road centreline and the step width shall be 500 mm per reconstructed layer. The number of 500 mm wide steps cut into the existing road pavement layers or between two new sections will be the same as the number of constructed pavement layers unless specified otherwise in the Contract Documentation.

When upper pavement layers are bladed or milled to windrow or taken to stockpile in order to expose the underlying layer that requires reconstruction, a transverse joint shall be constructed in the same manner as specified for the longitudinal joints, with each step being 500 mm wide per layer that is reconstructed or extended. The process of stepping back by 500 mm, doing the saw-cut and trimming up to the saw-cut, ahead of the next layer, shall continue until the base layer has been constructed.

Where use of a recycler is made to reconstruct a pavement layer in-situ, the transverse joint may be constructed using the recycler, without the use of saw-cutting equipment, as instructed by the Engineer or as specified in the Contract Documentation.

A5.3.3.8 Pavement layer drainage

Each compacted and completed pavement layer shall be adequately drained to prevent water from standing on or along the completed work.

Windrows shall be removed immediately after construction to facilitate the drainage of water off the surface and to prevent scouring of the completed work. On steep grades the Contractor may need to provide temporary berms to divert the water off the road surface at regular intervals.



Drainage in box cuts often not attended to

No material for a subsequent layer may be placed if the underlying pavement layer has been softened by moisture. The underlying pavement layer must first be allowed to dry out until the moisture content in the layer is below the optimum compaction moisture content. Any scouring of the pavement layer surface caused by storm water shall be repaired and the repairs approved by the Engineer before any material for the subsequent layer is placed.

If the underlying pavement layer cannot be adequately dried out or the water related damage cannot be satisfactorily repaired the affected layer shall be broken up and reprocessed at no cost to the Employer.

Where pavement layers are replaced over a section of the road width, or where pavement layers are widened and the permeability of the new layer is not the same as the adjacent existing layer, then subsoil drainage shall be installed along and below this interface as detailed and specified in the Contract Documentation.

A5.3.3.9 Pavement layer protection and maintenance

The Contractor shall protect and maintain the completed pavement layers at no cost to the Employer until the next layer or the surfacing has been constructed and thereafter until the works have been taken over by the Employer.

Maintenance shall include the closing off of the constructed pavement layers to all public traffic (except traffic for property access along the route by owners/tenants) and construction traffic except the vehicles hauling in the next layer of construction material and the immediate repair of any damage done to the layer or of any defects in the layer. Repairs shall be carried out as instructed by the Engineer. The Contractor shall ensure that an even and uniform surface is restored after completion of the repair work.

The base layer shall be primed as soon after construction as possible once the base layer has dried out sufficiently to a point where the moisture content, measured at any depth within the base layer, is below 50 % of the optimum moisture content for the material. No public or construction traffic shall be permitted on the completed base layer either before priming the layer or on the primed layer.

A5.3.3.10 Bound macadam (BM) layer protection and maintenance

The Contractor shall protect and maintain the completed bound macadam (BM) layer at no cost to the Employer until the next layer or the surfacing has been constructed and thereafter until the works have been taken over by the Employer. Maintenance shall include the immediate repair of any damage to the layer or of defects in the BM layer and shall be repeated as often as necessary. Repairs shall be carried out so as to ensure that an even and uniform surface is restored after completion of the repair work.

No public traffic (except traffic for property access along the route by owners/tenants) or construction traffic other than the prime distributor and the surfacing equipment shall be allowed on any completed BM layer.

A5.3.3.11 Water for pavement layers

Water for the construction of pavement layers shall comply with the requirements of Clause A4.1.5.18 of Chapter 4.

A5.3.3.12 Contractor prepared plans for the construction of pavement layers

The Contractor shall prepare and submit a management and utilization (M&U) plan for the construction of each individual pavement layer to ensure that it is worked in a sustainable and sensitive manner, that the environmental impact is minimised, material use and haulage are optimised and that costs are minimised.

The M&U plan shall at least take cognizance of the following and provide detail of the following as appropriate:

- The survey methods to be used to set out and control the levels and width of the pavement layers for each layer,
- A method statement and programme for the construction of each of the pavement layers from loading at the source of supply up to the completion of each layer,
- Risk assessment for ensuring the material can be taken to and used directly on the road to minimize any additional stockpiling on site,
- A method statement of how the pavement layers material will be prevented from sustaining storm water damage and from becoming excessively wet,
- A method statement for the construction of trial sections where specified or where requested by the Contractor and especially for stabilised layers, crushed stone layers and macadam layers,
- A method statement of how oversize material will be dealt with,
- A method statement of how work will be carried out in restricted areas,
- Measures to comply with the general and specific conditions of the road environmental management plan,
- Measures to comply with safety regulations and obligations in terms of the relevant Health and Safety Acts and Regulations,,
 - The full quality and process control testing detail for the applicable materials tests along with the frequency and quantity of such testing for each constructed section of each layer type to ensure full compliance of the constructed layer in terms of compaction density and material quality,
 - The full quality and process control testing, frequency and quantity of tests, for stabilised layers, visually and tests in the laboratory, and
- Procedures for regular monitoring, auditing and reporting.

M&U plans need to be submitted during the course of construction. The Contractor's construction programme shall set out by when each M&U plan will be submitted for review. The construction of a particular layer shall only commence once the Contractor's M-&U plan for that layer has been reviewed and accepted by the Engineer. The Engineer shall respond within one week after receiving an M&U plan.

A5.3.4 DESIGN BY THE CONTRACTOR/PERFORMANCE BASED SYSTEMS

The Contractor shall be permitted to submit an alternative pavement design as part of a performance based system.

A5.3.4.1 Catalogue pavement design

An alternative pavement design based on approved catalogue designs may be submitted when the average annual daily traffic (AADT) is less than 5 000. A 15-year pavement design life shall be required.

A5.3.4.2 Mechanistic pavement design

An alternative pavement design based on a mechanistic design process, may be submitted when the project details meet the following criteria;

a) AADT between 5 000 and 50 000

A 20-year pavement design life is required, and a full Life Cycle Cost Analysis shall be required for the alternative pavement design.

b) AADT in excess of 50 000

A 25-year pavement design life is required, and a full Life Cycle Cost Analysis shall be required for the alternative pavement design.

A5.3.4.3 Other pavement design methods

An alternative pavement design may also be submitted, based on other accepted pavement design methods such as AASHTO, DCP, Empirical or any other, when the project details meet the criteria of Clause A5.3.4.2. (Additional note: The Pavement Number method in TG2 Section 5.1 and Appendix C is a recognised South African alternative.)

A5.3.5 MATERIALS

A5.3.5.1 Material information

The required material properties for each individual pavement layer for a specific pavement design shall be clearly specified in the Contract Documentation.

The Contract Documentation shall specify which types of materials are to be used for a PMPL layer.

Any anticipated mechanical modification of material shall be stated in the Contract Documentation.

A5.3.5.2 Pavement layer thickness and compaction requirements

a) Pavement layer thickness requirements

The compacted pavement layer thickness shall be as specified in the Contract Documentation.

The thickness tolerances specified in Clause A5.3.8.4b) shall apply.

b) Gravel and soil pavement layer compaction requirements (G4B to G9 material)

The minimum compacted dry density of a gravel or soil pavement layer shall be as specified in Table A5.3.5-1 unless specified otherwise in the Contract Documentation.

Table A5.3.5-1: Minimum compaction densities for gravel and soil pavement layers

Layer	Compaction as % of maximum dry density (MDD)
Lower selected layer	93 %
Upper selected layer	95 % for gravel layers
	100 % for sand layers (97 % when specified in Contract Documentation)
Wearing course layer	95 %
Shoulder layer	95 %
Lower subbase layer	95 % for unstabilised layers
	95 % for chemically stabilised layers
	100 % for sand layers
Upper subbase layer	97 % for unstabilised layers
	95 % for chemically stabilised layers
	100 % for sand layers
Base layer	100 % for unstabilised layers
	97 % for chemically stabilised layers

In restricted areas the compacted dry density of the individual pavement layers shall also comply with the requirements given in Table A5.3.5-1 unless specified otherwise in the Contract Documentation.

c) Crushed stone pavement layer compaction requirements (G1 to G4A and G5A materials)

The minimum compacted dry density of a crushed stone pavement layer shall be as specified in Table A5.3.5-2 unless specified otherwise in the Contract Documentation.

Table A5.3.5-2: Minimum compaction densities for crushed stone pavement layers

Layer	Compaction as % Maximum Dry Density (MDD) or as % Bulk Density (BD) or as % Apparent Density (AD)
G4A and G5A lower subbase layer	95 % of MDD for unstabilised layers
	95 % of MDD for chemically stabilised layers
G3, G4A and G5A upper subbase layer	97 % of MDD for unstabilised layers

Layer	Compaction as % Maximum Dry Density (MDD) or as % Bulk Density (BD) or as % Apparent Density (AD)
	97 % of MDD for chemically stabilised layers
G3 and G4A base layer	98 % to 100 % of MDD (for G3 and G4A) or 85 % of BD for G3 only
G2 base layer	88 % of BD for Road category C and D (TRH 4, Table 1) 86 % of AD for Road category A and B (TRH 4, Table 1)
G1 base layer	86 % of AD for Road category C and D (TRH 4, Table 1 for road categories) 88 % of AD for Road category A and B (TRH 4, Table 1 for road categories)
PMPL pavement layer (lean mix concrete)	Cube crushing strength as specified in Contract Documentation. No density requirement.

The density of the compacted crushed stone base layers (G1 and G2 layers only) shall be tested to the full depth of the layer using a nuclear gauge.

In restricted areas the in-situ dry density of the crushed stone subbase and base layers shall also comply with the requirements given in Table A5.3.5-2 unless specified otherwise in the Contract Documentation.

d) Bound macadam (BM) layer

The minimum in-situ density of a BM layer shall be within the range as specified in Table A5.3.5-3. The Contract Documentation shall specify the actual applicable apparent density along with the construction method and the type of BM.

Either the dry-bound or wet-bound construction method can be used to construct the BM rock matrix.

Table A5.3.5-3: Minimum compaction density for BM pavement layers

Layer	Compaction density as % of apparent density (AD)
Bound macadam (BM) layer – dry-bound	84 % to 86 %
Bound macadam (BM) layer – water-bound	88 % to 90 %

After the construction of the BM rock matrix to the required compaction density the subsequent treatment of the compacted BM layer can vary and shall be specified in the Contract Documentation or instructed by the Engineer.

A5.3.5.3 Bound macadam layers

There are various BM layers that can be constructed, each with different material usage and different methods of construction.

The Contract Documentation shall specify which BM shall be constructed.

Table A5.3.5-4 describes the different BM layers.

Table A5.3.5-4: Different BM pavement layers

BM layer description	Key layer characteristics
Dry-bound macadam (DBM)	Single size rock matrix, usually 63 mm, filled with dry fine filler aggregate using compaction equipment only. Smooth swept surface.
Water-bound macadam (WBM)	A DBM slushed afterwards by saturating the filled rock matrix, usually 63 mm, and rolling with a steel drum roller. Where the climate does not allow the fine filler aggregate to dry sufficiently, it may be washed into the coarse aggregate. Smooth swept surface.
Partially penetrated macadam (PPM)	Construct a DBM or WBM. Broom away excess aggregate fines and some of the fine filler aggregate in the exposed open voids. Rough swept surface. Apply slurry which will therefore only penetrate partially.
Slurry-bound macadam (SBM)	Construct a PM followed by the application of a slurry using a crusher-sand/sand with emulsion. All voids to be completely filled with the emulsion slurry
Composite macadam (CM)	Construct the lower portion of the layer as a DBM or WBM. Construct the upper portion of layer of SBM using 50 mm or 37,5 mm aggregate. See Table A4.1.5-8.

A5.3.6 CONSTRUCTION EQUIPMENT

Construction equipment to carry out the construction of the pavement layers shall comply with the requirements of Clause A1.2.6 of Chapter 1.

A5.3.7 EXECUTION OF THE WORKS

A5.3.7.1 Controlling pavement layer thickness

a) Placing and spreading layer material

All material placed in position before compaction shall be spread evenly over the entire surface of each layer to be compacted and the quantity of material spread shall be such that each layer will comply with the requirements for thickness as specified in the Contract Documentation, when measured after compaction.

The Contractor shall ensure that segregation of the material into finer and coarser fractions does not occur during any of the stockpiling, loading, hauling, spreading and subsequent mixing operations.

b) Minimum pavement layer thickness in transition areas

Where the thickness of an existing gravel layer needs to be supplemented and the thickness of the added material after compaction will be less than 100 mm, the existing layer shall be scarified to a depth that will give a combined compacted layer thickness of at least 150 mm after compacting the loosened existing material and the added material as one layer unless specified otherwise in the Contract Documentation.

Where the thickness of an existing crushed stone subbase or base layer needs to be supplemented then the entire existing subbase or base layer shall be scarified and blended with the added material. The blended material forms a composite layer and it shall be compacted as a single layer if the compacted layer thickness will be less than 175 mm. The layer shall be compacted in two equal thickness layers when the final compacted layer thickness will exceed 175 mm unless the Contractor has demonstrated in a trial section that a thicker layer can be compacted successfully.

A5.3.7.2 Combining materials

The specific material requiring to be combined shall be specified in the Contract Documentation or the material shall be combined as instructed by the Engineer.

a) Combining materials from various sources in stockpile

Materials from various sources requiring mixing and that cannot be taken directly to the point of use, shall be stockpiled and subsequently loaded as specified in Clauses A4.1.7.2g) and A4.1.7.3b) of Chapter 4.

b) Combining recovered material

Recovered material from windrows, from stockpile floor areas, from oversize material, or from any area where there is an excess of material shall be combined and re-used. Screening, or crushing and screening, of the recovered material or combining it with some new material may also be required to comply with the material specifications of the layer for which it is subsequently to be used.

A5.3.7.3 Construction of gravel pavement layers

a) Construction

All material to be used for the construction of gravel pavement layers shall be checked at the source of supply for compliance with the material properties specified in Chapter 4 before being loaded and hauled to the point of use or to the central mixing plant for a PMPL pavement layer.

Oversize material up to a maximum of 5 % by compacted volume may be hauled to the point of use on the road where it shall be broken down by using appropriate compaction rollers. The remaining oversize material shall then be bladed out of the layer or removed by hand on the road. Where this material is hauled to a central mixing plant for a PMPL pavement layer, the material shall be screened and the oversize then loaded and hauled to a spoil site or to a crusher, for further processing.

Material containing more than 5% by volume of oversize material shall not be hauled to the point of use on the road unless it can be demonstrated that the oversize material can be broken down on the road and the Engineer has provided an instruction for this work to take place.

(Additional note: The last two paragraphs the same requirements as in Section 4.1 A4.1.7.2(i) and in Section A4.2.7.1(i))

When longitudinal construction joints are necessary, they shall be constructed in the positions detailed in the Contract Documentation.

Care shall be taken during the loading, hauling and dumping operations to prevent segregation of the material.

b) Breaking down pavement layer oversize material

Oversize material transported to the point of use as per Clause A5.3.7.3a) or oversize material already at the point of use, shall be broken down. The Contractor may employ any preferred methods and equipment to break down the material. However the effectiveness of the Contractors method shall be assessed against normal grid rolling, to establish the norm for the degree of breaking down to be attained by any alternative method.

Normal grid rolling shall be instructed by the Engineer and shall mean the following.

- (i) The material shall be placed or bladed to the one side of the road to provide working space for breaking-down the material.
- (ii) A portion of the material shall be spread in a thin layer on a compacted surface to promote effective breaking-down of the material, and to a width which the grid roller shall be able to cover in a single pass.
- (iii) The grid roller, which shall proceed at a speed of at least 12 km/h and shall have a minimum mass of 13,5 tons, shall do four complete roller passes over the material.
- (iv) Any material that is still oversize shall be removed and taken to a designated spoil site or to a crushing plant to be crushed
- (v) The broken-down material shall be placed in a windrow to the opposite side of the material still to be broken-down
- (vi) Repeat steps (ii) to (v), then place the second windrow next to the first windrow and mix the two windrows.
- (vii) Repeat steps (ii) to (vi) until all the material that needs to be broken down has been treated.

If normal grid rolling does not break down the material acceptably, the Engineer shall instruct either additional normal grid rolling, or crushing and screening to take place. Additional grid rolling means a repeat of the normal grid rolling detailed in points (i) to (vii) above.

c) With grader and conventional equipment

Before the pavement layer material is compacted, it shall first be thoroughly mixed by grader and disc plough, so as to obtain an even mix of the pavement material. The fine and coarse material shall be mixed evenly throughout the layer in the transverse, vertical and longitudinal direction.

Unless the material is already too wet, additional water shall be sprayed evenly over the spread pavement layer material using a water tanker.

d) With grader and specialised equipment

Before the pavement layer material is compacted, it shall first be thoroughly mixed using equipment such as a recycler so as to obtain an even mix of the pavement material. The fine and coarse material shall be mixed evenly throughout the layer in the transverse, vertical and longitudinal direction.

To ensure thorough mixing in a transverse direction when using a recycler, cross-mixing of the material may sometimes be required.

Unless the material is already too wet, additional water shall be sprayed evenly over the spread pavement layer material by the recycler during the final mixing pass.

The addition of water and mixing of the material can all take place simultaneously when a recycler is used.

e) Moisture control

The requirements of this clause e) are applicable to both clauses c) and d) above.

All additional water shall be uniformly mixed into the material to bring it to a moisture content to suit the specific compaction equipment used. When adding water, allowance shall be made for the loss of any water due to evaporation during the mixing and compaction operations which may occur under hot and/or windy weather conditions.

If the moisture content of the material is in excess of the compaction moisture content required to achieve the specified compaction density the wet material shall be replaced with dry material or processing shall cease and the material left to dry out until the required compaction moisture content has been reached. During compaction the material shall not display any signs of still being too wet, such as pumping or movement. The pavement layer material shall be compacted to the correct layer thickness and density as specified.

f) With paver and other equipment

Before the pavement layer material is compacted the mixture shall be spread and placed by a mechanical paver on the underlying layer to the required width and to a thickness and levels which are compliant with the tolerances specified in Clause A5.3.8 after final compaction. Segregation of the materials shall be prevented and the layer shall be free from pockets of coarse or fine materials.

Immediately prior to paving the material, the underlying layer shall be dampened and kept damp (not wet) until the layer is paved.

A5.3.7.4 Processing coarse gravel subbase or base layer (Additional note: New requirement and pay item.)

Coarse gravel containing mostly non-plastic or slightly plastic soil fines and used in the construction of a gravel subbase or base layer, shall require **slushing and rolling in addition to the specified compaction**, in order to obtain a firm, well-knit surface. **Additional note: This slushing is not the same as for a G1 base.**

After being processed and compacted, the layer may require to be well watered by the Contractor over short sections at a time and then slushed and rolled with pneumatic and/or vibratory compactors. Watering and rolling shall continue over a section until excess fines have been brought to the surface of the layer. **Such excess fines shall be uniformly spread over the entire surface of the layer by means of stiff mechanical or hand brooms.**

Watering, rolling and brooming shall continue until all surface areas deficient in fines have been corrected. All excess fines shall then be broomed off the surface of the layer without loosening the surface texture of the completed layer.

A5.3.7.5 Construction of gravel shoulder

Shoulder material shall be spread, watered, processed and compacted in accordance with the specifications for a pavement layer.

Where the gravel shoulder layer is to be constructed with the same gravel material as for the base layer, it shall be constructed simultaneously with the base layer.

Where a base is to be constructed with different gravel or with crushed stone material, the shoulders shall first be constructed and then neatly cut to the required line and level to provide lateral support for the edges of the new base layer material while it is being compacted. Care shall be taken not to contaminate the base material with the shoulder material. The Contractor shall ensure that the subbase layer and the base material that has not yet been compacted is adequately drained at all times by means of temporary drainage channels or pipes passing through the gravel shoulder layer.

Where an asphalt base layer is to be constructed, the shoulders shall be constructed after the completion of the asphalt base layer.

A5.3.7.6 Construction of crushed stone layer (Additional note: Crushed stone construction has been rewritten from the COLTO.)

a) Transportation of crushed stone subbase and base material

Compliant crushed-stone material shall be loaded at source, hauled to the road and off-loaded along the middle of the road width being constructed, in a pre-determined heap volume and spacing to ensure sufficient quantity so that the completed layer will comply with all the requirements in regard to layer thickness, level, cross-section and compaction density. Allowance shall also be made when determining the heap volume and spacing for sufficient additional material to be off-loaded to enable the layer to be properly mixed and cut to shape without segregation of the material taking place. Segregation is manifest by fine and/or coarse areas that develop in the exposed surface of the layer.

b) Processing of crushed stone subbase and base layer

The **day before spreading and mixing** the dumped material, the **heaps shall be flattened slightly**. The crushed stone **shall then be dampened**, by a watercart driving slowly over the flattened heaps. Watering shall cease when water starts to seep out from under the crushed stone heaps and the material shall then be left to stand until the next day. **Additional note: The requirement for a watercart driving over the flattened heaps can be relaxed, but it is important that the material be dampened the day before so that the fine aggregate has time to soak up moisture.**

Spreading and mixing of the material shall then be carried out, adding water as necessary. The water shall be sprayed on by means of a watercart. Mixing shall only be done by means of a grader by simultaneously watering and cutting the crushed stone from side to side across the underlying layer, starting from the middle of the layer width where the material was initially dumped. The grader shall move at an even pace with a fully laden blade. No material shall pass under the blade as this will result in segregation. The crushed stone shall be picked up cleanly from the underlying layer, and contamination by cutting into the underlying layer or an adjacent gravel shoulder shall be avoided. The optimum moisture content for compaction is correct when excess moisture becomes visible or glistens on the larger aggregate but just before the addition of any more water will result in the fine material being washed away.

Excessive mixing must be avoided as it tends to segregate the crushed stone and alter its grading.

After spreading and mixing of the material has been completed, the material must be shaped into a layer to the correct cross section, levels, thickness

and slope ready for compaction. Any shortfall in levels of the material must be corrected by adding crushed stone material. A shortfall over a length less than 20 m shall be corrected by mixing the additional material into the newly processed material by means of the ripper teeth of the grader, or alternatively to mix the additional crushed stone and water in the correct proportions in a large concrete mixer and spread the material over the shortfall area. When the shortfall occurs over a length that exceeds 20 m, all the material over at least 100 m shall be re-mixed with additional material.

c) Paver laid crushed stone subbase and base

The Contractor may elect to mix and spread crushed stone subbase and/or base material by means of a mixing plant and a paver unit. The construction of a trial section using this equipment shall be constructed before any crushed stone subbase or base layers are constructed on the underlying layer.

A5.3.7.7 Initial compaction of a G1 crushed stone base layer

Initial compaction of the crushed stone base layer shall commence immediately after completion of the spreading, dampening, mixing and shaping of the material as per Clause A5.3.7.6b). The Contractor shall provide compaction equipment that is capable of compacting the crushed stone layer to the required density using the process specified below.

Only a vibratory smooth drum roller or a combination of smooth drum and pneumatic tyre rollers shall be used for the initial compaction. Normally no grid or pad foot rollers shall be used as these rollers will alter the grading. The first pass of the vibratory roller shall be in static mode in order to smooth out the surface of the layer prior to compaction. Thereafter vibration at low frequency and high amplitude for compaction of the lower part of the layer shall be carried out, followed by vibration at high frequency and low amplitude for final compaction of the upper part of the layer.

To prevent shoving of the crushed stone, rollers shall always initiate compaction of a crushed stone layer from the outside edge of the road adjacent to the shoulder material towards the middle of the layer width on straight sections where there is a cross-fall. In a super elevation in a curve, the compaction shall commence from the lower or inner edge of the road towards the higher or outer edge.

The roller shall cover the entire road width equally. Compaction shall continue until the material is stable and displays no movement under the roller wheels and leaves no tyre marks of the roller in the crushed stone layer.

After the compaction is completed, a final slight full-width cut shall be carried out when necessary to ensure that the layer has no coarse or stony patches but an evenly-graded surface matrix. The layer must then again be rolled with pneumatic tyre or smooth drum static rollers to ensure that it is stable enough and ready for the final slush-compaction. The maximum compacted thickness of any crushed-stone layer compacted in one process shall be 150 mm, unless specified otherwise in the Contract Documentation.

A5.3.7.8 Slush-compaction of a G1 crushed stone base layer

After completion of the initial compaction of the crushed stone base layer, short sections of the layer surface, each section about 40 m to 60 m long, shall be thoroughly watered, rolled and slushed by means of steel wheeled rollers or a combination of steel wheel rollers and pneumatic tyre rollers. The Contractor shall provide compaction equipment that is capable of slush compacting the crushed stone layer to the required density using the process specified below.



Slush-compaction construction equipment



Surface during slush-compaction



Brooming of slush material

Slush-compaction shall start at the high side of the road so that the water can flow to the low side. No movement of the layer under the roller wheels shall be observable during the initiation of the slush-compaction. If the layer becomes unstable, it is an indication that insufficient bearing capacity has been achieved during the initial compaction. The slush-compaction shall then be halted, and the layer allowed to dry and subsequently to receive additional initial compaction before commencing again with the slush-compaction process.

The slush-compaction process shall continue until **fines are brought to the surface**. Fines shall mean sand or material larger than 0,075 mm up to 5,0 mm, and silt material smaller than 0,075 mm. The slush-compaction process is completed when the slushing water becomes clean and there is subsequently an absence of air bubbles being expelled from the layer.



Slush along road

The slush thus formed, shall be uniformly broomed over the surface to simultaneously correct any areas still deficient in fines, whereupon the excess fines shall be broomed from the surface of the layer. Brooming shall be done by using hand brooms, or by using mechanical rotary brooms with soft to medium stiffness bristles, or a combination of hand and mechanical brooms. Care shall be taken not to dislodge the coarse aggregate in the surface of the layer during the brooming process or otherwise disturb the aggregate mosaic.

During slushing operations, the surface must not be rolled out of shape. The slushing process shall be carried out on each short section in one continuous process, and each section shall be completed before the next section is commenced. After completion of the slushing and brooming process, when the surface of the layer is wind dry, the surface shall be given a one roller-pass with a static steel-wheeled roller. This finally embeds the surface aggregate.

The completed layer shall be firm and stable with a closely-knit surface of aggregate exposed in a mosaic pattern. The surface must have a good particle distribution without segregated areas of either excessive fines or of coarse material with a shortage of fines. The surface must be free from any lamination layers and free from corrugations. **The following characteristics are indicative of a well-constructed crushed stone layer:**

1. Most of the coarse aggregate lies on its largest surface dimension which is the most stable orientation.
2. The exposed surface of the layer, although textured, feels smooth.
3. All sizes of coarse aggregate larger than 5,0 mm can be seen.
4. The surface has a uniform appearance across and along the road.
5. The surface has a tightly interlocked mosaic of the coarse aggregate and less than 5 % of the mosaic area has only fine aggregate visible.
6. Less than 5 % breakdown of the larger particles by area.
7. The dried slush broomed off the road only comprises P0,075 mm silt.
8. Tapping the layer with a geological hammer produces a distinct high frequency or ringing sound.

Slush-compaction of the crushed stone base layer is mandatory and shall be carried out within 48 hours after completion of the initial compaction. Even if the specified density is achieved without slushing or before completion of the slushing process, the full slush-compaction process must still be completed.

Additional note: Slush-compaction is the least understood activity during the construction of a G1. A one-day course on the construction of a G1 is given through SARF, and attending it is highly recommended.)



G1 across road



Primed surface



G1 not good surface



G1 not good surface

A5.3.7.9 Construction of a plant mix paver laid (PMPL) layer

a) Mixing and transportation of PMPL material

Mixing shall be done at a location off the road by means of a central mixing plant. Mixing the materials on the road shall not be allowed. The method of introducing the various materials comprising the final mix shall be confirmed during the construction of the trial section. The method used shall consistently produce a mix with the required proportions. Any inconsistent mix shall be rejected.

The mixed material shall be loaded into the trucks used for transporting the material in such a manner that segregation of the material does not take place during loading.

The loss of moisture between the mixing moisture content and the compaction moisture content of the mixed material shall not be more than 5 % of the measured mixing moisture content. When necessary, the trucks shall be provided with protective covers to restrict the loss of moisture to less than 5 %.

b) Compacting a PMPL layer

(i) Crushed stone

(Additional note: PMPL crushed stone is not really carried in South Africa, although some engineers from the east who work in Africa do specify it.)

The spread mixture shall be compacted at or near the optimum moisture content. The moisture content added in the mixing plant shall make allowance for any moisture losses that may occur during loading, transporting or paving the material.

The completed compacted layer shall have a dry density of not less than that specified in the Contract Documentation and the Contractor may select any suitable compaction technique to achieve this required compaction, subject to the following construction limitations:

- The initial compaction shall be carried out with construction equipment that will achieve stability of the layer so that subsequent compaction can take place without displacement or deformation of the layer. The rolling pattern shall be so designed as to retain the shape of the layer;
- The compaction equipment shall be adequate for obtaining the specified density within the specified time limits in Table A5.4.3-1 when the PMPL material has been stabilised;
- The compaction equipment and techniques shall be capable of producing the specified surface level, layer density and finish; and
- If the PMPL crushed stone layer is stabilised then it shall not be slushed as specified for untreated crushed stone layers. If water is added during or after the compaction process to the stabilised mix, it shall be carefully controlled. Excessive application of water that will alter the ratio of the cementitious content to water (c/w ratio) at the compaction moisture content by more than 5 %, shall not be allowed.

(ii) Wet lean-mix concrete

Compaction to a specified density by normal rolling techniques will not be required, but the paver shall be fitted with a vibrating screed capable of thorough compaction of the material and striking it off to a smooth dense surface finish.

c) Construction joints

At the end of each single-operation, or when a single-operation is delayed or stopped for more than two hours, a construction joint with a vertical but unformed face, shall be made in the thoroughly compacted material, at right angles to the centre line of the road. Material that is not thoroughly compacted shall be removed to spoil.

PMPL material to continue with the progress of the single-operation or to commence the next single-operation shall not be placed until the construction joint has been prepared.

d) Finishing a PMPL layer

The stabilised crushed stone pavement layers and wet lean-mix concrete pavement layers shall have a uniform consistency.

All coarse and any other segregated areas shall be removed. The edges of the holes so formed shall be prepared in the same manner as a construction joint with vertical faces. The vertical faces shall be prepared with a slurry of cement and water. The holes shall then be backfilled with the same PMPL material as in the layer being repaired. The material shall be compacted to the same density as the layer by rolling or vibrating to suit the layer being patched and then finished off to the required level. Such patches shall be cured as specified in Section A5.4.

Any portion of the pavement layer which does not meet the specified strength, density and riding quality shall be removed and replaced at no cost to the Employer.

A5.3.7.10 Construction of a bound macadam (BM) layer

Before any BM layer is constructed, the following requirements shall be met:

- The underlying layer shall comply with the requirements for the layer concerned.
- The BM layer shall, where specified, be supported along the outer edges by edge restraints as detailed in the Contract Documentation
- A trial section shall have been constructed, tested and accepted as specified in the Contract Documentation.

a) Construction of an edge restraint

A concrete edge restraint such as a concrete channel, or a kerb and channel combination, or a gravel shoulder, shall be constructed to support the edge of the BM layer prior to the construction of the BM layer.

Concrete kerbs and channels serving as edge restraints shall not be displaced or damaged during construction activities. A gravel shoulder constructed as an edge restraint shall not be damaged during construction activities and shall not be allowed to contaminate the BM layer.

Any edge restraint damaged during construction shall immediately be replaced or repaired by the Contractor at no cost to the Employer.

b) BM construction methods

The BM layer shall be placed using labour enhancement and then compacted with conventional compaction equipment.

c) Spreading the aggregate

Compliant coarse aggregate shall be dumped in quantities sufficient to ensure that a layer of the specified final compacted thickness can be constructed. The dumped material shall be evenly spread by hand, or with a grader / mechanical paver to the line and level that will allow the compacted layer to comply with the final line, level and thickness required in the Contract Documentation.

Depth guides shall be used to control the thickness of the layer and the surface levels shall be checked at intervals of not more than 2,0 m. All high and low spots shall be corrected by removing or adding stone as required.

d) Initial compaction

This initial compaction process or dry rolling, is applicable for all the different BM layers listed in Table A5.3.5-4.

After the coarse aggregate has been spread, the layer shall be lightly compacted with appropriate rollers and any irregularities that may appear in the surface of the layer shall continue to be corrected by removing or adding coarse aggregate, as the case may be. This operation shall be repeated until the surface is uniformly smooth, free of irregularities and in accordance with the specified level and thickness tolerances.

Once the layer is free from irregularities it shall be compacted over its full width using low amplitude, high frequency, vibrating rollers of static mass

not less than 8 tons. Rolling shall progress gradually from the low side of the layer by uniformly lapping each preceding pass of the roller by one half the width of the roller drum and shall continue until the entire area of the layer has been covered. Rolling shall continue until the coarse aggregate has been thoroughly keyed and compacted and no movement of the aggregate under the rollers can be detected. The use of smaller vibratory rollers may be used in restricted areas or as instructed by the Engineer.

Should any irregularities exceeding 10 mm when tested with a 3,0 m straight edge, develop in the surface of the layer during the course of rolling, such irregularities shall be corrected by loosening the surface over the affected area and repacking the stone and rolling the area again until the level requirements are met. The Contractor shall use 28 mm size aggregate where necessary to take out minor slacks or depressions.

The compacted coarse aggregate layer shall not be left uncovered by fine material for any prolonged period. If any disturbance of the compacted stone layer occurs before the fine aggregate is spread over it, the stone layer shall be levelled again.

e) Adding fine aggregate and dry rolling

After completion of the initial dry rolling and the compacted coarse aggregate layer has been accepted, a layer of dry fine aggregate shall be evenly applied over the surface of the coarse aggregate in a layer thickness not exceeding 15 mm.

At the time of processing, the moisture content of the fine aggregate shall not exceed 4 %. Dry rolling shall be continued with vibrating rollers until all the fine aggregate has settled into the coarse aggregate. During this process it may be necessary to broom the surface with hand brooms to assist in the distribution of the fine aggregate. A further layer of fine aggregate shall then be applied and spreading, rolling and brooming of the fine aggregate shall continue until no more fine aggregate can be worked into the voids in the coarse aggregate.

All excess fines shall be swept off the surface to leave behind a tightly knit surface. An occasional light spray of water may be required to keep the surface adequately bound until it is primed.

f) Wet rolling and slushing

When no more fine aggregate can be worked in dry, the layer shall be well watered, using water tankers fitted with sprinkler bars to ensure an even application of the water, or applied by means of hand operated pressure sprayers. Additional fine aggregate shall be added when necessary and a slushing process consisting of watering, rolling and brooming shall commence using suitable pneumatic tyre rollers, in conjunction with suitable static steel drum rollers. The slushing process shall continue until a dense layer with minimum voids between the coarse aggregate and a firm base with a closely-knit surface, is obtained, free of areas of segregated materials, loose aggregate and any other irregularities.

All excess fines shall be swept off the surface and the layer shall be allowed to dry out sufficiently before proceeding with the next stage of the process.

g) Surface finish of BM layer

Excess BM material shall not be spread over the adjacent sidewalks, shoulders or the side fills, but shall be loaded and removed. The excess BM material shall not be re-used unless it has first been separated into its constituent parts and tested to ensure compliance with the material requirements.

The finished surface of the BM layer shall be true to level and cross-section, be uniform and smooth, free from corrugations, bumps and depressions.

Any section of base that remains non-compliant after standard remedial measures have been carried out shall be broken up and reconstructed. The non-compliant section of base shall be removed over the full depth of the layer including clearing the fine aggregate away and the section shall be reconstructed.

The BM layer shall then be further completed and surfaced as detailed in the Contract Documentation and specified in Chapter 10: Surface Treatments.

A5.3.7.11 Brooming and priming of BM layer

When the BM fine aggregate material has dried off to below 50 % of the OMC of the infill material for the BM layer, the surface shall be swept clean to remove any loose surface fines and other material that may have been deposited on the surface after it was compacted.

The brooming operation shall not remove fines from between the coarse aggregate. A rough and/or loose surface caused by incorrect brooming is not acceptable.

When the cleaned surface of the layer has been accepted, the prime coat shall be applied in accordance with the product details and application rates specified in the Contract Documentation and the specification in Chapter 10: Surface Treatments.

A5.3.7.12 Construction of trial sections

a) Trial sections

The trial section shall demonstrate the capability of the Contractor to construct the pavement layer or layers in accordance with the specification. The trial section shall be constructed with the same materials and equipment as those intended for use by the Contractor for the final pavement layer in the works. The surface regularity of any base layer in a trial section shall be checked for compliance.

A trial section shall be a full layer-width and at least 150 m long with a maximum length of 200 m. The minimum quantity of material to be crushed, stockpiled or hauled to site prior to the construction, testing and approval of the trial section shall be determined by the Contractor. Sufficient material should be produced or obtained from commercial sources so that the compliant material shall be representative of what will ultimately be produced for the entire project. The use of compliant material for the trial section shall not relieve the Contractor of the responsibility to produce a compliant finished layer.

The final length and width of the trial section which shall be specified in the Contract Documentation, shall be constructed in one continuous operation and shall then be submitted for approval. The Contractor shall also demonstrate the proposed method(s) to be used for making the construction joints.

The Contractor shall programme to proceed with the construction of the actual pavement layer in the works, at least 10 working days after the completion of the compliant trial section or such earlier time when testing of the trial section has been completed and the trial section has been accepted by the Engineer. In the event of a non-compliant trial section, the Engineer shall instruct the Contractor to construct a further trial section, which shall then be regarded as the initial trial section.

A non-compliant trial section shall be removed and disposed of by the Contractor at no cost to the Employer.

A compliant trial section shall be reimbursed only when it complies with all the requirements of the specification and has been accepted. The mixing process and equipment shall remain unaltered for all subsequent layer construction for which the trial section was constructed, unless otherwise instructed by the Engineer.

When the Contractor:

- changes the method of construction, or
- changes the construction equipment, or
- changes the materials, or
- changes the mix used, or
- changes the rate of paving for the construction of the layers in the works,

after the acceptance of a compliant trial section, the Engineer may instruct that a new trial section be constructed as specified in the Contract Documentation.

b) Compliant supporting layer for a trial section

The trial section for a stabilised layer, a crushed stone layer, a PMPL layer or a BM layer shall be constructed on a compliant supporting selected- or subbase layer. The supporting layer must be properly compacted to the specified density and be free from any defects.

If there are no constructed, compliant lower pavement layers ready to allow for the construction of the specific trial section at the programmed time in terms of the construction programme, the Contractor shall prepare a trial section area off the site of the works. This will enable the construction, testing and approval of a trial section to be carried out before excessive quantities of material are crushed and stockpiled.

The surface of the supporting or lower layer shall be dampened prior to placing and spreading the pavement layer material for the construction of the trial pavement layer on it.

c) Trial section for a stabilised layer

Before commencing the construction of stabilised layers the Contractor shall demonstrate by constructing a trial section that the proposed equipment and procedure to be used will result in constructing the layers in accordance with the specification.

The trial section shall be constructed in its proper position in the pavement. The stabilised material properties used for the trial section will be tested. One of the key properties shall be to establish if the agent is working as per the design. The surface finish obtained, the curing process as well as any potential stabilisation cracking, shall also be monitored and documented. Only when such a trial section has been satisfactorily constructed and accepted shall the Contractor be permitted to proceed with construction of the stabilised layer in the permanent work.

After acceptance of the trial section, the mixing process and equipment shall remain unaltered unless otherwise approved by the Engineer.

d) Trial section for a crushed stone layer

Before commencing with the construction of any crushed stone subbase or base layer the Contractor shall construct a trial section. The following Clauses listed in Table A5.3.7-1 are applicable for the construction of this trial section.

Table A5.3.7-1: Clauses applicable to the construction of crushed stone layers

Clause	Description
A5.3.7.6	Construction of crushed stone layer
A5.3.7.7	Initial compaction of a G1 crushed stone layer
A5.3.7.8	Slush-compaction of a G1 crushed stone layer

During the construction of the trial section these Clauses shall be validated and/or modified where necessary. Any resultant modifications of these Clauses shall then be implemented during the subsequent construction of the particular crushed stone layer.

The trial section shall establish or verify the following specific aspects:

- The spacing between the off-loaded heaps of crushed stone;
- Compaction moisture content and the compaction factor;
- Compaction passes, compaction frequency and roller amplitude settings;
- The pre-shape level to allow for settlement during compaction;
- The types and method of operation of compaction equipment during slush-compaction of G1 material;
- How long the slush-compaction process shall continue until there are no more air bubbles, the expelled water is clean and movement or 'heaving' under compaction has ceased;
- Brooming equipment and the brooming process;
- Progressive development of compaction density in the layer;
- Surface finish evaluation;
- Minimum construction base width where there is no shoulder containment, to ensure that the specified density is achieved across the full travelled roadway width;
- Grading and plasticity index, post-construction; and
- Approximate drying out time until the moisture content has been reached to allow the layer to be primed.
- The surface regularity shall be checked for compliance.

e) Trial section for a PMPL layer

Before commencing with the construction of the specified PMPL pavement layer in the works, the Contractor shall construct a trial section. The following Clauses listed in Table A5.3.7-2 are applicable to the construction of this trial section.

Table A5.3.7-2: Clauses applicable to the construction of a PMPL layer

Clause	Description
A5.3.7.3	Construction of gravel pavement layers
A5.3.7.9	Construction of a PMPL layer

During the construction of the trial section the specification of the Clauses referenced in Table A5.3.7-1 shall be validated and modified where necessary. Any resultant modifications of these Clauses shall be implemented during the subsequent construction of the PMPL layer in the works.

- The surface regularity shall be checked for compliance.

f) Trial section for a bound macadam (BM) layer

There are several types of BM layers. The Contract Documentation shall specify which specific BM layer shall be constructed for the project and this BM layer shall be constructed for the trial section. The different BM layers are listed in Table A5.3.5-4.

No BM pavement layer material, other than the compliant material required for the actual trial section, shall be placed on the road prior to the construction of a compliant BM trial section. Any modifications to the material or to the processing methods that result from the trial section shall be implemented for the construction of the BM pavement layer material.

The following Clauses listed in Table A5.3.7-3 are applicable to the construction of the BM trial section.

Table A5.3.7-3: Clauses applicable to the construction of a BM layer

Clause	Description	Construction comments
A5.3.7.10.1	Construction of an edge restraint	Required for all BM layers
A5.3.7.10.2	BM construction methods	Labour enhancement
A5.3.7.10.3	Spreading the aggregate	Use labour enhancement for all BM layer
A5.3.7.10.4	Initial compaction	Required for all BM layers
A5.3.7.10.5	Adding fine aggregate and dry rolling	Required for DBM, PPM and SBM
A5.3.7.10.6	Wet rolling and slushing	Required for WBM
A5.3.7.10.7	Surface finish of BM layer	As per the Contract Documentation and Chapter 10 : Surface Treatments
A5.3.8.3	'Rondavel' test (NITRR Technical Note TP/52/83)	84 % to 86 % of apparent density (AD) for all DBM
		88 % to 90 % of AD for all WBM

During the construction of the trial section the aspects of these Clauses shall be validated and modified where necessary. Any resultant modifications of these Clauses shall then be implemented during the subsequent construction of the BM pavement layer.

This trial section shall be constructed where it can be trafficked and monitored during the course of the project. The location of the trial section shall be as detailed in the Contract Documentation and could form part of the pavement for the deviation. The BM shall be constructed with edge restraints and on a subbase with the same specification as for the pavement design for the works. The performance of the layer in the trial section shall be assessed prior to acceptance thereof and use in the main works.

The trial section shall also be used to establish or verify the following aspects:

- The loose to tight compaction factors for the coarse aggregate.
- The loose volume of fine aggregate required per cubic metre of completed layer.
- The loose depth of coarse aggregate required to provide the specified final layer thickness.
- To establish or verify construction techniques, tools and procedures that will achieve the maximum possible density and produce the specified surface finish.
- To confirm the average density achieved by means of the 'Rondavel' test (Clause A5.3.8.3).
- To establish the optimum time to prime.
- The surface regularity shall be checked for compliance.

A5.3.7.13 Work in restricted areas

Work in restricted areas is specified in Clauses A1.1.3.2 and A1.2.3.23 of Chapter 1.

Spreading material in restricted areas shall be done in such a manner that the required level and grading standards can be attained. Suitable equipment and methods shall be used in restricted areas so that the required densities are obtained throughout the thickness of the layer. Where the compaction apparatus used is of such a nature that the material in thicker layers cannot be properly compacted, the Engineer shall instruct that material be placed and compacted in layers of as thin as 75 mm.

The Engineer may, in restricted areas, permit the contractor to spread, water and mix the gravel or crushed stone in a windrow next to the pavement excavation. The existing surfacing shall not be damaged and the mixed material shall not be mixed with any deleterious material. Where this method of mixing is impractical or impossible and mixing on adjacent surfaces is not permitted, mixing shall be done in a central mixing plant or in the case of small quantities, suitable portable concrete mixers may be used. (Additional note: Rather place an ETB iso a crushed stone in these small areas.) Irrespective of the layer concerned, the mixing shall be of such quality that a uniform mix shall be obtained.

Where any construction work is being done adjacent to an existing surfacing, the existing surfacing shall not be damaged.

A5.3.8 WORKMANSHIP

A5.3.8.1 Inspection of the works

The Engineer shall do routine inspections and conduct routine tests to determine whether the quality of material and workmanship provided, complies with the requirements of the Contract Documentation.

A5.3.8.2 Material quality and compaction requirements

Compaction testing shall be done within 24 hours of the layer being constructed.

The test results and measurements shall be assessed in accordance with the provisions of Chapter 20: Quality Assurance.

All damage done to a completed layer during any testing procedure shall be repaired and made good as instructed by the Engineer at no cost to the Employer.

A5.3.8.3 Bound macadam (BM) layer compaction requirements

The density of the completed BM layer shall be tested using the 'Rondavel' test described in NITRR Technical Note TP/52/83. Density tests shall be carried out at a frequency of approximately one test per 50 m³ of compacted BM layer.

In addition, a proof rolling test shall be carried out to establish if there is any audible grinding of the coarse aggregate or visible movement in the layer as the roller passes over. Audible grinding indicates that full interlock of the stone has not been achieved, nor has maximum density been attained. Additional 'Rondavel' tests shall then be done to further investigate any suspect areas detected during this inspection.

The density requirements shall be deemed to have been satisfied provided that the test results of the section tested exceed the apparent density (AD) as achieved in the successful trial section.

A5.3.8.4 Construction tolerances for pavement layers

The values specified below apply to a layer thickness of 150 mm or more. For layers with a thickness less than 150 mm, more stringent tolerance values may be specified in the Contract Documentation.

a) Level tolerances

For all layers the level tolerances referred to in Chapter 20: Quality Assurance shall be as given in Table A5.3.8-1.

Table A5.3.8-1: Pavement layer level tolerances (H = road elevation)

Layer		H ₉₀	H _{max}
Selected layer		25 mm	33 mm
Subbase layer		15 mm	20 mm
Base layer	Crushed stone or gravel	12 mm	15 mm
	Bound macadam	20 mm	25 mm
Shoulder and wearing course layer		n/a	25 mm

Level control for the different pavement layers shall be done at the following intervals given in Table A5.3.8-2:

Table A5.3.8-2: Pavement layer level control intervals

Layer		Longitudinal interval	Transverse interval
Selected, sub-base, shoulder and wearing course layers		20 m	Centre-line, yellow line and outer edges plus at intermediate mid-points
Base layer	Crushed stone or gravel	10 m	Centre-line, yellow line and outer edges plus at intermediate mid-points
	Bound macadam	10 m	Centre-line, yellow line and outer edges plus at intermediate mid-points

b) Layer thickness tolerances

The thickness tolerances referred to in Chapter 20: Quality Assurance shall be as given in Table A5.3.8-3. Layer thicknesses shall be established from the difference in actual levels taken on the preceding layer, and not from the design levels, and levels taken on the layer under consideration.

Table A5.3.8-3: Pavement layer thickness tolerances (D = layer depth or thickness) (Additional note: more strict than COLTO.)

Layer	D_{90}	D_{max}	D_{ave}
Selected layer	25 mm	35 mm	8,0 mm
Subbase layer	18 mm	24 mm	5,0 mm
Base layer	15 mm	22 mm	5,0 mm
Shoulders and wearing course layer	None	30 mm	0 mm
Bound macadam layer	21 mm	27 mm	5,0 mm

c) Grade tolerances

Deviations from the specified longitudinal grade shall not exceed the values given in Table A5.3.8-4 in respect of the specified grades on the completed base. These allowable deviations are also valid for BM base layers:

Table A5.3.8-4: Pavement layer grade tolerances

Length (l) of section under review (m)	Maximum deviation (g) of specified slope (%)
2	0,354 %
5	0,224 %
10	0,158 %
20	0,112 %
30	0,091 %

The following formula shall be applicable for any other lengths (l) over which the grade deviations may be calculated:

$$g(\%) = \frac{0.5}{\sqrt{l}}$$

d) Width tolerances

The average width of the layer shall not be less than the specified width, and nowhere shall the outer edge deviate by more than the measurement shown in Table A5.3.8-5 from the designed road edge lines shown in the Contract Documentation:

Table A5.3.8-5: Pavement layer width tolerances

Layer	Maximum deviation from designed edge lines
Selected layer	80 mm
Subbase layer	75 mm
Base layer	50 mm

Layer	Maximum deviation from designed edge lines
Shoulders and wearing course layer	75 mm

e) Cross-fall and cross-section regularity

When tested with a 3,0 m straightedge laid at right angles to the road centre line, the surface of any layer shall not deviate from the bottom of the straightedge by more than 6,0 mm.

For BM base layers only, when a 3,0 m straight-edge is laid on the finished surface, the gap between the straightedge and the coarse aggregate in the surface shall not at any point exceed 10 mm when placed either parallel or at right angles to the centreline of the road.

At any cross-section, the difference in level between any two points shall not vary from their difference in level computed from the cross-sections shown on the drawings by more than 15 mm.

A5.3.8.5 Surface regularity

Surface regularity, or riding quality of the **base layer**, shall be assessed by one or more of the following methods as specified in the Contract Documentation.

a) By using a 3,0 m straight-edge

A 3,0 m long straight-edge with sharp right-angled corners at the bottom as well as a tapered wedge, shall be used for measuring irregularities on the base layer. The straight-edge shall be placed on the road and measurements taken by inserting the thin edge of the wedge below the straight-edge. Measurements shall be done in each wheel path of each lane or shoulder randomly, at not more than 10 m apart.

The maximum value of an individual surface irregularity measured at any point with a 3,0 m straight-edge, shall not exceed 10 mm.

b) By using a rolling straight-edge

Before each day's measurements are taken, the rolling straight-edge shall be calibrated.

For measuring the irregularities, measurements shall be done in each wheel path of each lane or shoulder over the full length of the section. The number of surface irregularities shall not exceed those given below:

- The average number of irregularities per 100 m equal to or exceeding 5,0 mm when taken in wheel paths over 300 m to 600 m lengths..... ≤ 3
- The number of irregularities equal to or exceeding 5,0 mm when taken over 100 m lengths..... ≤ 4

The maximum deviation for each wheel path must also be recorded and shall not exceed 10 mm.

c) By using a profiler

An inertial laser profilometer or a Walking Profiler capable of producing a Class 1 vertical measurement resolution, and a Class 3 longitudinal sampling distance as defined in ASTM standard (E950-09), shall be used to determine the roughness of the base layer in the case of ;

- newly constructed base layers; and
- where an existing base layer or part thereof (in depth) is rehabilitated by reconstruction or by recycling over the full width of a traffic lane or on a shoulder that is wider than 2,0 m to be surfaced. Shoulders with a width of less than 2.0 m to be surfaced, shall be assessed according to measurements obtained from the adjacent lane.

The profilers shall be furnished and operated by the Contractor in the presence of the Engineer. Prior to using an inertial laser profilometer, it shall have successfully completed a validation trial against the Instrument of Reference used by the Employer.

The **inertial laser profilometer or Class 1 Walking Profiler** shall be used to record the longitudinal profile in both wheel tracks of each traffic lane or shoulder wider than 2,0 m, as determined according to the final line/lane markings that will be applied on the road surface after completion of construction. For the inertial laser profilometer, three repeated runs shall be carried out. For the Class 1 Walking Profiler only a single measurement will be required per wheel track. The two wheel tracks shall be 1,75 m apart. Should the two wheel tracks not be measured simultaneously during the same pass, then procedures shall be implemented to ensure that the longitudinal profile data recorded for the two wheel tracks are at the same longitudinal location on the road.



Inertial laser profilometer



Walking profiler

The measured longitudinal profiles will then be processed using the Quarter-Car simulation model with parameter values as defined in ASTM standard (E1170-97) for Ride Meter-Vehicle Mounted. The simulated suspension mentioned will then be linearly accumulated and divided by the length to yield 100 m IRI (International Roughness Index) values in units of mm/m or m/km for each wheel track. The last 50 m and the joining first 50 m of adjacent sections will be evaluated as a 100 m section in the direction of vehicle travel. Where the works is of such a nature that public traffic needs to cross the constructed base layer to gain access to and from adjacent properties, the Contractor shall identify these positions beforehand. A width of minimum 10 m and maximum 20 m may be identified for each access / crossing. The IRI values for each of these sections shall be excluded from the individual 100 m section values being evaluated.

For inertial laser profilometer measurements the left and the right 100 m IRI values from the three runs for each measured lane will then be averaged to produce the average IRI as follows:

$$\text{Run1 IRI}_{100 \text{ m ave}} = (100 \text{ m IRI}_{\text{Left wheel track}} + 100 \text{ m IRI}_{\text{Right Wheel track}}) / 2$$

$$\text{Run2 IRI}_{100 \text{ m ave}} = (100 \text{ m IRI}_{\text{Left wheel track}} + 100 \text{ m IRI}_{\text{Right Wheel track}}) / 2$$

$$\text{Run3 IRI}_{100 \text{ m ave}} = (100 \text{ m IRI}_{\text{Left wheel track}} + 100 \text{ m IRI}_{\text{Right Wheel track}}) / 2$$

$$\text{Average IRI}_{100 \text{ m}} = (\text{Run1 IRI}_{100 \text{ m Ave}} + \text{Run2 IRI}_{100 \text{ m Ave}} + \text{Run3 IRI}_{100 \text{ m Ave}}) / 3$$

For the Class 1 Walking Profiler measurements, the Average IRI will be calculated as follows:

$$\text{Average IRI}_{100 \text{ m}} = (100 \text{ m IRI}_{\text{Left wheel track}} + 100 \text{ m IRI}_{\text{Right Wheel track}}) / 2$$

The Average IRI_{100 m} values shall then be evaluated and judged according to Table A5.3.8-6 to determine whether the 100 m section needs corrective work or payment adjustments.

Table A5.3.8-6: Payment adjustment for base layer

Average IRI _{100 m} (m/km)	Payment adjustment factor		
	Reworked or Recycled Base	Recycle existing layers and new base layer	New pavement construction
<1.50	1.050	1.050	1.050
1.51 to 1.60	1.050	1.050	1.025
1.61 to 1.70	1.050	1.050	1.010
1.71 to 1.80	1.050	1.050	1.000
1.81 to 1.90	1.050	1.025	0.990
1.91 to 2.00	1.050	1.010	0.975
2.01 to 2.10	1.050	1.000	0.955
2.11 to 2.20	1.025	0.990	0.930
2.21 to 2.30	1.010	0.975	0.900
2.31 to 2.40	1.000	0.955	0.865
2.41 to 2.50	0.990	0.930	Reject
2.51 to 2.60	0.975	0.900	Reject
2.61 to 2.70	0.955	0.865	Reject
2.71 to 2.80	0.930	Reject	Reject
2.81 to 2.90	0.900	Reject	Reject
2.91 to 3.00	0.865	Reject	Reject
>3.01	Reject	Reject	Reject

Adjustment to the payment for the base will be reflected separately in the Contractor's monthly certification of the works. The adjustment will be calculated by multiplying the full payment value for each 100m section, for payment items *** _____ by the payment adjustment factor derived from Table A5.3.8-6. Contract Price Adjustment shall not be applicable to the payment adjustment for the base. The payment adjustment shall apply to the total base layer width placed over the 100m section in question.

Surfaced shoulders less than 2,0 m wide will be assumed to have the same roughness measurements as the adjacent lane and the quantity of material in the shoulder shall be added to the quantity of material of the adjacent lane for determination of the payment adjustment factor.

On sections where the Average IRI_{100 m} is worse than the cut-off value listed in the Contract Documentation the section shall be rejected and corrective work shall be necessary.

Any corrective work required shall be made by the removal of the total base layer width placed, over the 100 m section in question, followed by reinstatement. Surfaced shoulders less than 2,0 m wide shall be treated the same as the adjacent slow lane. Corrective work shall not commence until the Engineer has reviewed the Contractor's method statement. If the Contractor proposes any other corrective procedure he shall apply to the Engineer for the Employer's approval of the proposal. Corrective work shall be done at no cost to the Employer and shall be completed prior to determining the pavement thickness. After completion of the corrective work, the 100 m sections shall be re-evaluated according to the specifications.

Where the base layer is surfaced with an asphalt surfacing subject to a surface regularity specification contained under Clause A9.1.8.4 of Chapter 9, the Contractor may choose to leave the base layer over the 100m section in question in place. In such an event, the maximum negative payment adjustment factor obtained from Table A5.3.6-6 shall be applied to the section in question. The average IRI_{100 m} before the construction of the asphalt surfacing (IRI_{b Ave}) required to determine the target IRI for the asphalt surfacing as defined in Clause A9.1.8.4 of Chapter 9 shall be determined for the section in question as follows:

Determine the base 100 m sections applicable to a lot (or section) of asphalt intended to be paved in one day's production. Determine the 100 m base section so identified with the highest achieved IRI value. This value will be used as the input value for the IRI_{b Ave} for the section in question.

The longitudinal profile and the 100 m International Roughness Index (IRI) values shall be determined using an inertial laser profilometer or a Class 1 Walking Profiler furnished and operated by the Contractor or on behalf of the Contractor in the presence of the Engineer. Prior to using an inertial laser profilometer it shall have successfully completed a validation trial against the Instrument of Reference namely the Class 1 Walking Profiler, used by the Employer.

As an absolute minimum the longitudinal profile shall be measured as soon as a 2000 m section of lane or shoulder is completed. Where shorter than 2000 m sections of a layer is required to be constructed the section as a whole will be measured as soon as it is completed. The contractor shall be paid for these measurements under payment item B81.05. No additional payment will be made to the Contractor for additional measurement and analysis of profiles when ordered by the Contractor for own assessment purposes, or if additional surveys are required as a result of any remedial / corrective work identified and subsequently completed.

For new base layers and rehabilitation of existing base layers where the layer or part thereof (in depth) is required to be reworked or recycled over a length of less than 600 m and over the full width of a traffic lane or shoulder the roughness of the layer will be determined by using a Class 1 Walking Profiler.

The raw measurements from the inertial laser profilometer or Walking Profiler will be uploaded to SANRAL through the SARDS Quality Assurance module.

*(***Note to compiler: Insert the relevant base layer construction pay items but exclude pay items for additives such as cement and bitumen)*

B5.3 ROAD PAVEMENT LAYERS

PART B: LABOUR ENHANCEMENT

B5.3.1 SCOPE

B5.3.2 DEFINITIONS

B5.3.3 GENERAL

B5.3.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

B5.3.5 MATERIALS

B5.3.6 CONSTRUCTION EQUIPMENT

B5.3.7 EXECUTION OF THE WORKS

B5.3.8 WORKMANSHIP

B5.3.1 SCOPE

This Section covers the preparation of the roadbed/subgrade on an existing alignment, the construction of selected subgrade layers (where applicable), subbase, bases (unstabilised and treated/stabilised in accordance with Section A5.4: Stabilisation), wearing courses and shoulders with natural and crushed gravel using labour enhanced methods of construction and light plant.

Material for the road pavement layers is produced as specified in the relevant Sections of Chapter 4.

The addition and mixing of stabilising agents either as an integral part of the PMPL process or for some of the conventionally placed road pavement layers that require treatment and/or stabilisation is specified in Section A5.4.

The reconstruction of existing road pavement layers is specified in Section A5.5.

(Additional note: This is the only Part B in the Sections of Chapters 4 and 5 that has an extensive specification for Labour Enhanced construction.)

B5.3.2 DEFINITIONS

Definitions as provided in Clause A5.3.2 apply.

B5.3.3 GENERAL

Any activity specified in Part A, where hand work is given as an alternative, shall be executed in such a way as to maximise labour.

The relevant specifications of A5.3.3 of Part A shall be applicable.

B5.3.4 DESIGN BY THE CONTRACTOR/PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply.

B5.3.5 MATERIALS

B5.3.5.1 Material information

The required material properties for each individual pavement layer for a specific pavement design shall be clearly specified in the Contract Documentation.

B5.3.5.2 Pavement layer thickness and compaction requirements

a) Pavement layer thickness requirements

The compacted pavement **layer thickness** shall be as specified in the Contract Documentation. Layer thicknesses of layers constructed using labour enhanced methods of construction shall be restricted to **maximum of 100 mm**.

The thickness tolerances specified in Clause A5.3.8.4b) shall apply.

b) Gravel and soil pavement layer compaction requirements (G4B to G9 material)

The compacted dry density of a gravel or soil pavement layer shall be as specified in Table A5.3.5-1 unless specified otherwise in the Contract Documentation shall apply.

Where **no density specification is specified** for layers constructed by labour and light plant, the integrity and workmanship of each trial section shall be assessed by **Dynamic Cone Penetrometer (DCP)** and shall comply with the following *in situ* readings:

The average of 4 DCP readings randomly chosen to cover the entire trial section and expressed in mm/blow, shall not exceed the following figures:

- Gravel Base/Wearing course - 4
- Gravel Subbase layer - 9
- Gravel Upper Subgrade - 18
- Gravel Lower Subgrade - 25

(Additional note: Apply the above DN values with caution. They are for Low Volume Roads and then differ for the various traffic classes. The DCP-DN values are also affected by moisture and aggregate grading. Below are 2 tables from the publication "ReCAP Pavement design of LVR using the DCP-DN method, September 2020." The above DN values correspond only to a max traffic class 0,1 E80s in table 7.1. For higher traffic classes stronger materials (lower DN values) are required. Table 7.3 then shows that poorer base material can be used where the subgrade has improved material (again lower DN values).)

Table 7-1: Standard DCP-DN Design Catalogue

Traffic Class MESA	TLC 0.03 0.01-0.03	TLC 0.1 0.03-0.10	TLC 0.3 0.1-0.3	TLC 0.7 0.3-0.7	TLC 1.0 0.7-1.0
0- 150 mm Base ≥ 98% Mod. AASHTO	DN ≤ 6.2	DN ≤ 4.4	DN ≤ 3.2	DN ≤ 2.5	DN ≤ 2.3
150-300 mm Sub-base ≥ 95% Mod. AASHTO	DN ≤ 13	DN ≤ 9	DN ≤ 6.6	DN ≤ 5.2	DN ≤ 4.7
300-450 mm Subgrade ≥ 95% Mod. AASHTO	DN ≤ 21	DN ≤ 15	DN ≤ 11	DN ≤ 8.7	DN ≤ 7.8
450-600 mm In situ material	DN ≤ 32	DN ≤ 23	DN ≤ 17	DN ≤ 13	DN ≤ 12
600-800 mm In situ material	DN ≤ 48	DN ≤ 34	DN ≤ 25	DN ≤ 19	DN ≤ 17
DSN ₈₀₀	≥ 52	≥ 73	≥ 100	≥ 128	≥ 143

Source: Adapted from Kleyn and van Zyl (1988)

Table 7-3: DCP-DN Design Catalogue for BN₁₀₀ = 24%

Traffic Class MESA	TLC 0.03 0.01-0.03	TLC 0.1 0.03-0.10	TLC 0.3 0.1-0.3	TLC 0.7 0.3-0.7	TLC 1.0 0.7-1.0
0- 150 mm Base ≥ 98% Mod. AASHTO	DN ≤ 8.5	DN ≤ 6.0	DN ≤ 4.4	DN ≤ 3.4	DN ≤ 3.1
150-300 mm Sub-base ≥ 95% Mod. AASHTO	DN ≤ 12	DN ≤ 8.8	DN ≤ 6.4	DN ≤ 5.1	DN ≤ 4.6
300-450 mm Subgrade ≥ 95% Mod. AASHTO	DN ≤ 17	DN ≤ 12	DN ≤ 8.9	DN ≤ 7.0	DN ≤ 6.3
450-600 mm In situ material	DN ≤ 23	DN ≤ 16	DN ≤ 12	DN ≤ 9	DN ≤ 8
600-800 mm In situ material	DN ≤ 30	DN ≤ 21	DN ≤ 16	DN ≤ 12	DN ≤ 11
DSN ₈₀₀	≥ 52	≥ 73	≥ 100	≥ 128	≥ 143

Source: Adapted from Kleyn and van Zyl (1988)

B5.3.6 CONSTRUCTION EQUIPMENT

Construction equipment to carry out the construction of the pavement layers shall comply with the requirements of Clause A1.2.6 of Chapter 1.

The following specialised plant and equipment shall be used to promote the construction of the layer with labour enhancement:

- Suitably sized (approximately **1 ton**) **tandem vibratory pedestrian rollers** having two equally sized drums in tandem - both drums driven, each drum to have a separate eccentric shaft
- Steel angle formwork (shutters), 150 mm x 100 mm x 6,0 mm thick (1 m, 2 m and 3 m lengths)
- Steel spacer plates (bulking rails), 75 mm x 6,0 mm and 50 mm x 6,0 mm capable of slotting onto the steel angle formwork to form a continuous shutter for levelling the loose material (1 m, 2 m and 3 m lengths)
- 75 mm x 75 mm and 50 mm x 50 mm steel box sections for tying in levels of new work with previously constructed work (1 m, 2 m, and 3 m lengths)
- Steel squeegees
- Screeding boards comprising steel or aluminum straight edge of suitable length for screeding loose material
- Plastic sheeting
- Cross fall templates of 2 % or 3 % as specified
- Steel pegs of various lengths (Y10)

- String or sisal, 3,0 mm white
- Water tank on LDV or mounted on trailer with pump, 1000 litres
- Wheelbarrows
- Shovels
- Brooms
- Steel tape, 50 m

B5.3.7 EXECUTION OF THE WORKS

B5.3.7.1 Controlling pavement layer thickness

Steel side forms shall be used during the placing and spreading of the pavement layer material. The steel angle formwork shall have dimensions conforming to 150 mm x 100 mm x 6,0 mm thick and be available in 3 m, 2 m and 1 m lengths or as specified in the Contract Documentation. The shorter lengths of angle formwork are for use with smaller radius curves.

Sufficient steel forms for one day's work shall be available.

All material placed in position before compaction shall be spread evenly over the entire surface of the layer concerned and the quantity of material spread shall be such that every layer will comply with the requirements for thickness as specified in the Contract Documentation, when measured after compaction.

The Contractor shall ensure that segregation of the material into finer and coarser fractions does not occur in any of the stockpiling, loading, hauling, spreading and subsequent mixing operations.

B5.3.7.2 Mechanical modification of pavement layer material

The relevant specifications of A5.3.7.2 of Part A shall be applicable.

B5.3.7.3 Construction of gravel pavement layers

a) Construction

All material to be used for the construction of gravel pavement layers shall be checked at the source of supply for compliance with the material properties specified in Chapter 4 before being loaded and hauled to the road construction area or to the central mixing plant.

Oversize material up to a maximum of 5 % by compacted volume can be hauled to the point of use on the road or to the central mixing plant. The oversize material shall then be removed by hand on the road and then loaded and hauled to a spoil site.

The distance over which the material is to be carted from the gravel heaps to be placed on the road shall be minimised.

To facilitate the achievement of this objective where material is hauled by trucks from borrow pits to the work area, it should be strived to use trucks of the same measured and known capacity (e.g. 6 m³, 7 m³ or 10 m³, etc.).

The spacing of the gravel heaps delivered by the truck/s shall be established by the Contractor calculations, based on the loose thickness to which the material shall be placed.

The spacing of each truck load shall be demarcated and controlled by means of markers on the surface of the road.

b) Construction with labour enhancement

The day before spreading and mixing the dumped material, the heaps shall be dampened.

The heaped gravel material shall be brought to and maintained at optimum moisture content (OMC) immediately prior to placement on the road, and the material shall be protected against drying out during the construction process using plastic sheets.

(i) Placing of steel side forms (shutters)

Care shall be taken when fixing the steel formwork to ensure that no bumps are built into the surface and that a smooth vertical and horizontal alignment is obtained.

The steel formwork shall be firmly and correctly placed so as to comply with the specified dimensions, lines and levels of the road or section to be constructed.

Once the steel side forms have been placed, the levels shall again be checked (by string lining across the tops of the side forms) and the surfaced trimmed to ensure that the correct thickness of pavement layer is laid.

(ii) Placing of the layer

Before placing the layer, the lower layer shall be lightly watered.

The material for the layer being constructed shall be wheelbarrow placed between the steel side forms at a uniform spacing to achieve a minimum amount of material relocation when the loose material is screeded/levelled to the required depth of 1,5 times the compacted depth.

Calculation of the spacing of the wheelbarrow loads shall be done by the Contractor.

A steel spacer plate (bulking rail) shall be placed on top of the 150 mm or 100 mm flange of the steel side forms to obtain a height of 225 mm or 150 mm (depending on the required compacted thickness of the layer – 100 mm or 150 mm). Using the steel squeegees and steel screed bar the material shall be spread level with the top of the spacer plate to obtain a 225 mm or 150 mm thick loose layer. No pedestrian traffic shall be allowed onto the loose layer before screening or compaction.

Where the layer is constructed adjacent to previously constructed work a suitably sized spacer shall be placed on top of the existing work to obtain the correct loose thickness for the new work.

When using coarse material over-sized fractions shall be removed from the surface and replaced with finer material to achieve the required smooth finish.

A plastic sheet shall be rolled out over the layer as the work progresses in order to inhibit the material drying out.

(iii) **Compaction of the layer**

Once 8,0 m to 10,0 m in length of the layer has been completed, the plastic sheet may be rolled up and compaction may commence.

Compaction with an approved pedestrian roller in vibratory mode shall be executed until the loose layer, as determined by the spacer plate, has been compacted to the top edge of the vertical flange of the steel side form.

Rolling shall commence at a 45° angle to the edge line of the shutters and shall thereafter continue in such a manner that the roller is always supported over approximately a half of its width initially either on an existing surface or the steel side forms.

Compaction shall be done in vibratory mode, parallel to the shutter lines, moving from both sides inward towards the middle of the layer in increments of slightly less than half the width of the roller, after each pass of the roller.

B5.3.7.5 Construction of gravel shoulder

The construction of gravel shoulders using labour enhancement shall be constructed as specified in Clause B5.3.7.3a) and b).

B5.3.7.6 Construction of composite bound macadam (BM) layers

The recommended layer thickness for a composite bound macadam layer, constructed using labour enhancement is limited to 100 mm. The bottom part is constructed as either a water-bound or a dry-bound macadam. The maximum thickness of the bottom part is 70 mm if light pedestrian compactors are used. Light pedestrian walk behind rollers can be used to compact and orientate the bottom part of the coarse aggregate prior to the application of the filler sand. The light vibratory pedestrian rollers may also be used to vibrate the filler sand into the voids. If a thicker layer is constructed, the density specification as per Part A will still apply which implies the use of heavier rollers.

The upper part shall be a slurry bound macadam layer done in accordance with specifications in Chapter 10.

B5.3.7.7 Construction of trial sections

The trial section shall demonstrate the capability of the Contractor to construct the pavement layer in accordance with the specification using labour enhancement.

The trial section shall be constructed with the same materials and equipment as those intended for use by the Contractor for the final pavement layer in the works.

An eight-metre long trial section shall be constructed on a suitably prepared and located position as directed by the Engineer for compliance to the specification. Only once approved by the Engineer may the Contractor proceed to construct the specific layer in its proper location on the road under construction.

A compliant trial section shall be reimbursed only when it complies with all the requirements of the specification and has been accepted. The mixing process and equipment shall remain unaltered for all subsequent layer construction for which the trial section was constructed, unless otherwise instructed by the Engineer.

If after acceptance of the trial section, the Contractor

- changes the method of construction, or
- changes the construction equipment, or
- changes the materials, or
- changes the mix used, or
- changes the rate of paving for the construction of the layers in the works, or
- the Contractor has difficulty in attaining the specified level of workmanship;

then the Engineer may instruct that a new trial section be constructed.

B5.3.8 WORKMANSHIP

B5.3.8.1 Inspection of the works

The provisions of Part A shall apply.

C5.3 ROAD PAVEMENT LAYERS

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the constructional plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Items that will not be measured separately

The following required activities will not be measured or paid for separately and the Contractor shall include the cost thereof in other items as deemed appropriate:

1. All surveying, setting out and level control required for the construction of the pavement layers.
2. Drainage and protection of the pavement layers from all damage that may occur for any reason until the Employer has taken over the works.
3. Protection of all existing or new kerbs, channels, sidewalks, lined drains, catch pits, kerb inlets, gratings, culverts, bridges, structures, buildings, road signs, guard rails, street lights, fencing, service pipes or cables and any other items adjacent to, over or under the road that could be damaged by the Contractor's vehicles, construction equipment, or by public traffic being accommodated on or alongside the pavement layers, during the construction of the pavement layers, until the Employer has taken over the works.
4. Compaction immediately adjacent to existing or new kerbs, channels, sidewalks, lined drains, catch pits, kerb inlets, gratings, culverts, bridges, structures, buildings, road signs, guard rails, street lights, fencing, service pipes or cables etc. using hand operated compaction equipment.
5. Repair of all damage to the pavement layers and any new or existing structures, buildings, road furniture and services that may occur for any reason before, during or after the construction of the pavement layers up until the Employer has taken over the works.
6. Provision of additional material in excess of the compacted volume of the layers calculated using the layer dimensions given in the Contract Documentation for whatever reason including additional material required for the correct placing, mixing, levelling and compaction of the layers.
7. Removal of additional material required for the correct mixing and working of the layers and left in windrow or on the sides of the road.
8. Breaking down and removal of oversize material up to 5 % of the compacted layer volume. Payment will only be made to remove any oversize material in excess of 5 % of the compacted layer volume that cannot be broken down on the road when instructed by the Engineer.
9. Loading and hauling of commercial pavement material identified by the Employer or by the Contractor.
10. Loading and hauling of alternative material identified by the Contractor.
11. Construction of tie-in joints to new or existing road layers or surfacing.

(iii) Items to be measured and paid for using payment items specified elsewhere in the specifications

For activities in Table C5.3-1 payment items specified in other Chapters or Sections of the specification, where they relate to work under this Section, will be listed in the Pricing Schedule.

Table C5.3-1: Payment items from other Chapters or Sections

Activity	Section 5.3 reference	Section item reference
Loading and hauling	A5.3.1	Section C1.7 of Chapter 1 – All applicable items
Stabilisation	A5.3.1	Section C5.4 of Chapter 5 – All applicable items
Subsoil drainage	A5.3.3.8	Section C3.1 of Chapter 3 – All applicable items
Asphalt base layer	A5.3.7.5	Section C9.1 of Chapter 9 – All applicable items
Bound macadam surfacing	A5.3.7.10g)	C10.1.2 of Chapter 10
Construction of edge constraints for BM	A5.3.7.10a)	Section C11.1 of Chapter 11 – All applicable items
Priming	A5.3.3.9 / 10	Chapter 10 – All applicable items
Screening material	A5.4.7.2d)	Section C4.1 of Chapter 4 – All applicable items
Emulsion slurry	Table A5.3.5-4	Section C10.1 of Chapter 10 – All applicable items

(iv) **Items specifically for this Section of the specifications**

Item	Description	Unit
C5.3.1	Compiling and implementing M&U plans for the construction of all the pavement layers	number (no)

The unit of measurement shall be the number of compiled M&U plans for the construction of the pavement layers.

Usually only one plan shall be required for each of the layers unless specified otherwise in the Contract Documentation.

The tendered rate shall include full compensation for gathering all information and compiling the plan(s) and for ensuring the implementation of the plan(s) during the construction of the pavement layers.

Item	Description	Unit
C5.3.2	Construction of pavement layers	
C5.3.2.1	Construction of layers using conventional construction methods:	
(a)	Lower selected subgrade layer (layer thickness indicated) compacted to 93 % of MDD	cubic metre (m ³)
(b)	Lower selected subgrade layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(c)	Upper selected subgrade layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(d)	Upper selected subgrade layer (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(e)	Sand layer (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(f)	Sand layer (layer thickness indicated) compacted to 100 % of MDD	cubic metre (m ³)
(g)	Gravel wearing course layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(h)	Gravel shoulder layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(i)	Lower subbase gravel layer (unstabilised) (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(j)	Lower subbase gravel layer (chemically stabilised) (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(k)	Upper subbase gravel layer (unstabilised), (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(l)	Upper subbase gravel layer (chemically stabilised), (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(m)	Gravel base layer (unstabilised), (layer thickness indicated) compacted to 100 % of MDD	cubic metre (m ³)
(n)	Gravel base layer (chemically stabilised), (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(o)	G5B crushed rock/boulder subbase layer (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(p)	G5B crushed rock/boulder base layer (layer thickness indicated) compacted to 100 % of MDD	cubic metre (m ³)
(q)	G5A crushed rock/boulder subbase layer (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(r)	G5A crushed rock/boulder base layer (layer thickness indicated) compacted to 100 % of MDD	cubic metre (m ³)
(s)	G4A crushed rock/boulder lower subbase layer (unstabilised or chemically stabilised) (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(t)	G4A crushed rock/boulder upper subbase layer (unstabilised or chemically stabilised) (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(u)	G4A crushed rock/boulder subbase layer compacted to 97 % of MDD	cubic metre (m ³)
(v)	G3 crushed stone subbase layer (unstabilised or chemically stabilised) (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(w)	G3 crushed stone base layer (layer thickness indicated) compacted to 85 % of BD	cubic metre (m ³)
(x)	G2 crushed stone base layer (layer thickness indicated) compacted to 88 % of BD	cubic metre (m ³)
(y)	G2 crushed stone base layer (layer thickness indicated) compacted to 88 % of AD	cubic metre (m ³)
(z)	G1 crushed stone base layer (layer thickness indicated) compacted to 86 % of AD	cubic metre (m ³)
(aa)	G1 crushed stone base layer (layer thickness indicated) compacted to 88 % of AD	cubic metre (m ³)
(bb)	Bound macadam layer (layer thickness indicated) compacted to 90 % of AD	cubic metre (m ³)
(cc)	PMPL wet lean-mix concrete layer (Cube crushing strength and layer thickness indicated)	cubic metre (m ³)

C5.3.2.2 Construction of layers using labour enhancement:

(a)	Lower selected subgrade layer (layer thickness indicated) compacted to 93 % of MDD	cubic metre (m ³)
(b)	Upper selected subgrade layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(c)	Sand layer (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(d)	Sand layer (layer thickness indicated) compacted to 100 % of MDD	cubic metre (m ³)
(e)	Gravel wearing course layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(f)	Gravel shoulder layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(g)	Lower gravel subbase layer (layer thickness indicated) compacted to 95 % of MDD	cubic metre (m ³)
(h)	Upper gravel subbase layer (layer thickness indicated) compacted to 97 % of MDD	cubic metre (m ³)
(i)	Gravel base layer (layer thickness indicated) compacted to 98 % of MDD	cubic metre (m ³)
(j)	Gravel base layer (layer thickness indicated) compacted to 100 % of MDD	cubic metre (m ³)
(k)	Bound macadam layer (layer thickness indicated) compacted to 90 % of AD	cubic metre (m ³)
(l)	Soil cement or soilcrete (layer thickness indicated) wet mixture as per clause A4.1.5.14	cubic metre (m ³)
(m)	Soil cement or soilcrete (layer thickness indicated) stiff mixture as per clause A4.1.5.14	cubic metre (m ³)
(n)	Emulsion treated base material (G1 or G2 material and layer thickness indicated) as per clause A4.1.5.15	cubic metre (m ³)

The unit of measurement shall be the cubic metre of material in the compacted layer, calculated using the layer work dimensions given in the Contract Documentation.

The tendered rates shall include full compensation for spreading the material, for breaking down oversize gravel material using one normal grid rolling operation or an equivalent operation, for removal of up to 5 % of the compacted layer volume of oversize material that cannot be broken down, for adding water for compaction purposes, for mixing, for levelling, for compacting to the specified density, for slush-compaction of G1 material layers or other layer that may be specified to receive slush-compaction and for finishing the layers in accordance with the specifications and the Contract Documentation. The tendered rates shall also include for the removal of all material in the windrow after the compaction of the layer has been completed.

Measurement and payment for loading the layer work material from borrow pits, quarries, cuttings, reclaimed material from existing roads and alternative materials identified by the Employer, transporting and then off-loading the material at the point of use is made under items C1.7.1 and C1.7.2 of Chapter 1.

The haul of the imported material shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

A distinction shall be made between construction using conventional construction methods and labour enhancement.

Item	Description	Unit
C5.3.3	Construction of crushed stone base supplied by the Employer	cubic metre (m³)

This item is for crushed stone base constructed from type G1 or G2 material supplied from the Employer's stockpile (state location of stockpile) at R..... per ton (layer thickness indicated) and compacted to 88 % AD or 86% AD respectively as specified in the Contract Documentation..

The unit of measurement shall be the cubic metre of completed crushed-stone base in-situ and compacted to the specified density. The quantity shall be calculated from the net authorised dimensions of the layer as shown on the drawings or prescribed by the engineer. No adjustments shall be made to the net specified dimensions for level and thickness tolerances, overbuilding and/or other wastage.

The tendered rate shall include compensation for the purchase of the material from the Employer at R..... per ton, weighing on the calibrated weighbridge, furnishing and placing all materials, including crusher fines for correcting the grading of the crushed-stone and hauling the material to the point of use, rolling slushing and correcting the layers, and for testing, protecting and maintaining the work all as specified. (Additional note: The Contractor must carry out some tests during the tender stage to verify the grading of the material.)

Item	Description	Unit
C5.3.4	Deductions for G1 crushed stone base material supplied by the Employer	ton (t)

The unit of measurement shall be the ton of material supplied by the Employer.

The value of material supplied by the Employer and to be deducted from payments due to the contractor, shall be determined as the sum of audited weighbridge documentation and delivery notes.

Item	Description	Unit
C5.3.5	Breaking down oversize gravel layer material on the road	
C5.3.5.1	By additional normal grid rolling as per clause A5.3.7.3b)	square metre-pass (m ² -pass)
C5.3.5.2	By tamping roller	square metre-pass (m ² -pass)
C5.3.5.3	By pad foot vibratory roller	square metre-pass (m ² -pass)
C5.3.5.4	By vibratory roller	square metre-pass (m ² -pass)

The unit of measurement shall be the square metre-pass calculated by multiplying the layer surface area covered by the agreed number of roller-passes used to break down the material satisfactorily.

The tendered rate for each square metre-pass instructed by the Engineer shall include full compensation for all supervision, labour, equipment, fuel, materials, work and incidentals necessary for completing the work. The same rates shall be applicable should there be a reduction in the number of roller-passes for a specific type of roller.

The tendered rate shall include full compensation for supplying the roller and removing the roller after completion of the breaking down process.

The items shall differentiate between the different types of rollers used.

Item	Description	Unit
C5.3.6	Removal of oversize material	cubic metre (m³)

The unit of measurement shall be the cubic metre of oversize material which cannot be broken down on the road and is removed for re-crushing or removed to spoil as instructed by the Engineer in excess of the 5 % of the compacted layer volume of oversize material included in the rates tendered for item C5.3.2.

The volume measured for payment shall be taken as 70 % of the loose volume in excess of 5 % of the measured volume of the layer as measured in the haul vehicles.

The tendered rate shall include full compensation for removing the oversize material from the pavement layers, loading it into the hauling vehicles and off-loading it at the point of disposal.

The haul of the oversize material in excess of 5 % by volume per layer shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

Item	Description	Unit
C5.3.7	Recombining recovered material	cubic metre (m³)

The unit of measurement shall be the cubic metre of the recombined material added to and mixed into the pavement layer as specified in Clause A5.3.7.2. The volume measured for payment shall be taken as 70 % of the loose volume of recovered material as measured in the haul vehicles.

The tendered rate shall include full compensation for mixing the recombined recovered material binder into the layer to form one homogeneous layer.

Payment for the construction operations required to process and compact the recombined layer will be paid for under item C5.3.2 and other relevant items

The haul of the recovered material shall be measured from the point of loading/collection to the point of off-loading as per Section A1.7 of Chapter 1.

Item	Description	Unit
C5.3.8	Processing of coarse gravel subbase or base layers (New item)	cubic metre (m³)

The unit of measurement shall be the cubic metre of material in the compacted layer calculated using the layer work dimensions given in the Contract Documentation.

The tendered rate shall include full compensation for carrying out the processing and finishing work for a coarse layer as specified in Clause A5.3.7.4.

Item	Description	Unit
C5.3.9	Construction of a trial section	

C5.3.9.1 Construction of a trial section using conventional methods of construction

(a)	Stabilised gravel layer (layer thickness indicated) trial section	cubic metre (m ³)
(b)	Crushed stone subbase layer (layer thickness indicated) trial section	cubic metre (m ³)
(c)	Crushed stone base layer (layer thickness indicated) trial section	cubic metre (m ³)
(d)	PMPL layer (layer thickness indicated) trial section	cubic metre (m ³)
(e)	Bound macadam layer (layer thickness indicated) trial section	cubic metre (m ³)
(f)	Any other	cubic metre (m ³)

C5.3.9.2 Construction of a trial section using labour enhancement methods

(a)	Stabilised gravel layer (layer thickness indicated) trial section	cubic metre (m ³)
(b)	Gravel base layer (layer thickness indicated) trial section	cubic metre (m ³)
(c)	Bound macadam layer (layer thickness indicated) trial section	cubic metre (m ³)
(d)	Any other	cubic metre (m ³)

The unit of measurement shall be the cubic metre of layer trial section constructed, tested and accepted. The quantity shall be calculated based on the authorised dimensions of the trial section layer.

The tendered rate shall include full compensation for providing all the material and constructing the particular layer for the trial section as specified. The tendered rate shall also include for any costs associated with a **delay up to a maximum of ten working days**, to allow for testing between completion of the trial section and the acceptance thereof.

A distinction shall be made between construction using conventional construction and labour enhancement.

Item	Description	Unit
C5.3.10	Removal of a completed trial section	
C5.3.10.1	Stabilised layer	cubic metre (m ³)
C5.3.10.2	PMPL layer	cubic metre (m ³)
C5.3.10.3	Crushed stone layer	cubic metre (m ³)

The unit of measurement shall be the cubic metre of compliant trial section layer removed to a designated site when instructed by the Engineer.

The tendered rates shall include full compensation for breaking up the trial section layer and for loading the broken up layer material..

The haul of the material to the designated site as instructed by the Engineer and off-loading the material shall be measured from the point of loading/collection at the trial section to the point of off-loading as per Section A1.7 of Chapter 1.

The removal to spoil of a non-compliant trial section layer shall be done by the Contractor at no cost to the Employer.

Item	Description	Unit
C5.3.11	Riding quality measurements	
C5.3.11.1	Using a 3,0 m straight edge	kilometre (km)
C5.3.11.2	Using a rolling straight edge	kilometre (km)
C5.3.11.3	Using an inertial profilometer	kilometre (km)

The unit of measurement shall be the kilometre of riding quality measurements taken in each wheel path, measured along the wheel path as specified in Clause A5.3.8.5.

The tendered rates shall include full compensation for the cost of all traffic accommodation arrangements required, for several possible establishments and de-establishments of testing equipment, for the measurement of the riding quality with the specified instrument and the processing, analysis and interpretation of the riding quality measurements.

Item	Description	Unit
C5.3.12	Surface regularity payment adjustments	Provisional Sum (Prov Sum)

The unit of measurement shall be the cumulative monetary value of each 100 m section of the completed base layer as measured and paid under item C5.3.2, multiplied by the applicable payment adjustment factor obtained from Table A5.3.8-6.

QUESTIONS?

BREAK!

2.6. Section 5.4 - Stabilisation

5.4 STABILISATION

CONTENTS

PART A: SPECIFICATIONS

- A5.4.1 SCOPE
- A5.4.2 DEFINITIONS
- A5.4.3 GENERAL
- A5.4.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS
- A5.4.5 MATERIALS
- A5.4.6 CONSTRUCTION EQUIPMENT
- A5.4.7 EXECUTION OF THE WORKS
- A5.4.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

A5.4 STABILISATION

PART A: SPECIFICATIONS

A5.4.1 SCOPE

This Section covers the work requirements for the treatment of the material properties of natural roadbed, fill layers or pavement layers and crushed material by stabilisation, all in terms of the definition of Stabilisation in Clause A4.4.2 of Chapter 4. **(Additional note: The pavement layer construction and compaction are covered in Section 5.3 and 5.5. The stabilisation designs are covered in Section 4.4.)**

A5.4.2 DEFINITIONS

The relevant definitions in the standard specifications are applicable. Additional definitions for this Section are included here.

Mechanical modification - mechanical modification, also referred to as granular stabilisation, is a form of stabilisation as defined in Clause A4.4.2 of Chapter 4. Mechanical modification of a pavement layer involves the addition and mixing together of various materials from different sources to produce a uniformly mixed material that is compliant with the properties required for the pavement layer for which the modified material is being used.

Lamination layer - a term used to describe the layer formed when a compacted layer delaminates and forms loose and unbonded layers on top of the layer when incorrect compaction techniques are used. A colloquial term, biscuit layer, is also used for the lamination layers.

Breaking of emulsion - this term describes the process that occurs when the suspended bitumen in the emulsion separates from the water and the water evaporates, leaving behind bitumen. It is also referred to as the setting of the emulsion.

Filler - a filler is a commercially available product. A filler is often a cementitious agent. The quantity added is sufficient to result in improvement of the properties of the material it is added to, but insufficient to result in the stabilisation of the material should the filler have been added in isolation.

A5.4.3 GENERAL

A5.4.3.1 Stabilisation agents

The type and quantity of cementitious or bituminous stabilisation agent to be used for each layer of material shall be determined as described in Clauses A4.4.7.1c) and A4.4.7.1d) of Chapter 4.

The different types of cementitious and stabilisation agents are specified in Clauses A4.4.5.2, A4.4.5.3 and A4.4.5.4 respectively of Chapter 4.

Should a non-traditional stabilising or soil treatment agent be proposed by the Contractor, it will only be considered if the requested details specified in Clause 4.4.5.4 of Chapter 4 are provided.

A5.4.3.2 Work in restricted areas

Work in restricted areas is specified in Clauses A1.1.3.2 and A1.2.3.23 of Chapter 1.

Where pavement layers are to be treated or stabilised in restricted areas such as widenings, no cementitious or bituminous agent may be spread or mixed beyond the required width. **The Contractor shall not be permitted to mix the material being stabilised on an adjacent paved surface.**

Where restricted areas are such that mixing in the restricted area is impractical and mixing on adjacent surfaces is not permitted, mixing shall be done in a central mixing plant. In the case of small quantities, suitable portable concrete mixers may be used.

Treatment and stabilisation of layer work materials in restricted areas shall not be measured separately for payment unless specified otherwise in the Contract Documentation.

A5.4.3.3 Construction limitations

The Contractor shall programme all construction work to take into account all the construction limitations which are applicable to soil treatment and

stabilisation work.

a) Size of area

The cementitious and/or bituminous agent shall only be applied to a surface area the size of which will permit all processing, watering, compacting and finishing to be completed within the time periods specified in Table A5.4.3-1.

b) Processing time

The construction methods and programme of the Contractor shall take into account and ensure compliance with the processing times specified in Table A5.4.3-1.

Table A5.4.3-1: Construction time limitations for treatment and stabilisation⁽¹⁾

Chemical agent	Maximum continuous period allowed from the time the application of the chemical agent onto the top of the layer commences up until the completion of the stabilisation process
Material modification	
Lime	10 hours. The treated layer shall subsequently remain undisturbed for 24 hours.
Material cementation	
Cement blends	6 hours until the completion of the compacted layer (Additional note: COLTO 8 hrs.)
Lime	10 hours until the completion of the compacted layer
Material improvement	Additional note: new requirement.
Bitumen emulsion	12 hours until the completion of the compacted layer
Bitumen emulsion with cement	8 hours until the completion of the compacted layer
Foamed bitumen with or without cement	10 hours until the completion of the layer
PMPL stabilised crushed stone material	Additional note: new requirement.
Cement blends	1 hour until the commencement of compaction plus 4 hours until the completion of the compacted layer.
Wet lean-mix concrete	150 minutes until the completion of the compacted/vibrated layer (reference temperature = 20°C This time shall be reduced by 30 minutes for every 5°C that the mix temperature exceeds 20°C

Note (1): The construction time limitations shall not exceed the field working time established during the stabilisation design in Clause A4.4.7.1 of Chapter 4.

c) Trial section approval and testing time

The construction programme and methods of the Contractor shall take into account and ensure compliance with the limitations applicable to the construction, testing and acceptance of the trial section/s as specified.

d) Weather restrictions (Additional note: The weather restrictions are new.)

No stabilisation shall be done during windy conditions, wind speed more than 15 km/h (4 m/s), wet weather and cold weather when the air temperature is below 3°C or with falling air temperatures, 7°C and falling. (Additional note: 15 km/h is exceeded when loose paper and dust are raised)

No stabilisation work shall be commenced if the surface temperature of a compacted stabilised layer may fall below 1°C during the first three (3) days after stabilisation. The Contractor shall take the necessary precautions and the construction programme for the stabilisation work shall take the actual and predicted weather conditions into account.

All stabilised layers damaged by rain, frost or by the formation of ice in the layer shall be removed and replaced by the Contractor at no cost to the Employer.

e) Traffic limitations

No vehicles or construction equipment except that used for mixing the stabilising agent into the layer shall be allowed to travel over the spread stabilising agent.

No traffic or construction equipment except that required for curing or priming shall be allowed to travel over the compacted stabilised layer during the specified curing period as per Clause A5.4.7.6, unless specified otherwise in the Contract Documentation.

A5.4.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Not required for Section A5.4.

A5.4.5 MATERIALS

A5.4.5.1 General

For chemically stabilised layers the natural material or the reclaimed road material, even if previously stabilised, shall comply with the requirements of Table A4.4.5-2 in Chapter 4.

For bitumen stabilised layers the natural material or the reclaimed road material, even if previously stabilised, shall comply with the requirements in Table A4.4.5-3 in Chapter 4.

All commercial materials proposed for use by the Contractor or as specified in the Contract Documentation to be stabilised, shall comply with the requirements of Table A4.4.5-2 or Table A4.4.5-3 in Chapter 4 as applicable.

A5.4.5.2 Material for modification or pretreatment

Material with non-compliant properties, such as the grading, plasticity index and/or CBR strength, that are not compliant for direct use in a stabilised layer, shall first be mechanically modified and/or chemically pretreated as specified in the Contract Documentation or as instructed by the Engineer.

The materials to be modified shall be identified in the Contract Documentation or by the Engineer during construction and shall be modified to produce compliant material before any chemical stabilisation is carried out.

a) Mechanical pretreatment of material before stabilisation

Material requiring mechanical modification to improve the grading and/or moderate the plasticity index and/or to increase the CBR strength, **in order for the material to be compliant before stabilisation shall first be prepared and/or treated as specified in Section A5.3.**

The mechanically modified compliant material shall **then be stabilised** with the type and amount of stabilising agent specified in the Contract Documentation or as instructed by the Engineer.

b) Cementitious pretreatment of material before stabilisation

Material requiring modification to reduce the plasticity index in order for the material to be compliant for subsequent stabilisation, shall **first be pretreated.**

The chemically pretreated, modified and now compliant material shall **then be stabilised** with the type and amount of cementitious stabilising agent determined as specified in the Contract Documentation or as instructed by the Engineer.

A5.4.5.3 Cementitious stabilising agents

The Contract Documentation shall specify the type of cementitious agent to be used for the specific gravel or crushed stone material being chemically pretreated or stabilised. These nominal contents shall then be verified or adjusted based on the laboratory test results and/or after the construction of a trial section.

A5.4.5.4 Bituminous stabilising agents

The Contract Documentation shall specify the type of bituminous agent to be used for the project for the specific gravel or crushed stone material being stabilised. These nominal contents shall then be verified or adjusted, based on the laboratory test results and/or after the construction of a trial section.

A5.4.5.6 Water for stabilisation

Water for the construction of stabilised layers shall comply with the requirements of Clause A4.1.5.18 of Chapter 4.

A5.4.6 CONSTRUCTION EQUIPMENT

Construction equipment to carry out the stabilisation or modification of layer work material shall comply with the requirements of Clause A1.2.6 of Chapter 1.

When either a rotary mixer or a recycler is used to mix in the stabilising agent and process the layer, this construction equipment must be capable of adding variable but precise amounts of water, and then mixing and placing the material in a single pass in conformance with the design grades and cross falls.

Where specified in the Contract Documentation, the watering for the curing of compacted stabilised layers shall be done by side-spraying tankers travelling off the layer.

A5.4.7 EXECUTION OF THE WORKS

A5.4.7.1 Construction of a trial section

The Contractor shall demonstrate by constructing one or more of the following trial sections that the equipment and procedure to be used will result in the construction of layers in accordance with the specifications. The required trial section(s) shall be in accord with the pricing schedule.

- A trial section for the chemical modification or stabilisation of a layer of material processed on the road shall be constructed in accordance with the relevant requirements of Clauses A5.3.7.12 and A5.4.7 and/or as specified in the Contract Documentation.
- A trial section for the bituminous stabilisation of a layer of material processed on the road shall be constructed in accordance with the requirements of Clauses A5.3.7 and A5.5.7 and/or as specified in the Contract Documentation.
- A trial section for the cementitious stabilisation of PMPL materials shall be constructed in accordance with the requirements of Clause A5.3.7 and/or as specified in the Contract Documentation.

To allow sufficient time to test and assess all aspects of a trial section(s) and to determine the final content of stabilising agent required, the Contractor shall **programme to start stabilisation work for the works no sooner than 10 working days after completion of the trial section.**

Should the Contractor make any alterations to the methods, processes, equipment or materials used, or if the Contractor is unable to consistently comply with the specifications due to variations in the in-situ material, or for any other reason, further trial sections shall be constructed for assessment before continuing with the construction of the permanent works as instructed by the Engineer.

In the event of a trial section not being accepted due to non-compliance, the Contractor shall remove the trial section and construct a new trial section at no cost to the Employer. The trial section shall be paid for separately only when it complies with all the requirements of these specifications and has been accepted. Once acceptance of the trial section has been obtained, the mixing process and construction equipment shall remain unaltered unless instructed otherwise by the Engineer.

A5.4.7.2 Mechanical modification of pavement layer material

The specific layer material requiring to be mechanically modified shall be specified in the Contract Documentation or instructed by the Engineer.

When two or perhaps three different pavement layer materials need to be blended in order to provide a compliant composite material the proportion of each material type shall be specified based on the test results obtained from site blending trials.

a) Mixing materials from various sources in-situ

This Clause for mixing materials from various sources shall only apply when the smallest component of the materials mixture exceeds 20 % of the total mass of the mixture.

The material from the coarsest material source shall be placed onto the road at the point of use and spread in a layer of uniform thickness after which it shall be lightly rolled with a steel-wheeled roller. The material from the second and possibly third material source shall then be placed on top of the spread layer and then evenly spread on top in a layer of uniform thickness. After spreading each subsequent layer, each layer shall be lightly rolled with a steel-wheeled roller. After evenly spreading the different materials on top of each other, the materials shall be thoroughly mixed together, broken down if required and then spread evenly again to the required thickness.

The Contractor shall take care to avoid segregation from occurring during the mixing and spreading processes. The grading of the mixed material shall then be tested at random locations as instructed by the Engineer and further mixing shall be required if grading tests indicate that the material is not mixed sufficiently.

The finally mixed material shall also be tested for compliance with the specification of all the material properties for use in the specific layer.

b) Modifying material in-situ by the addition of a soil binder

When the smallest component is less or equal to 20 % of the total mass of the mixture then the process shall be regarded as the addition of a soil binder. The addition of the soil binder may be required to modify the grading or to reduce the plasticity index.

The material to be modified shall be placed onto the road at the point of use and evenly spread in a layer of uniform thickness after which it shall be lightly rolled with a steel-wheeled roller. The specified soil binder material shall then be placed on top of the evenly spread material and then evenly spread in a layer of uniform thickness over the first layer of spread material. The soil binder and material shall be thoroughly mixed together, broken down if required and then spread evenly to the required thickness.

The grading and plasticity index of the mixed material shall then be tested at random locations as instructed by the Engineer and the modified material shall be tested for compliance with the specification for use in the specific layer.

A5.4.7.3 Chemical pretreatment and stabilisation

The material to be stabilised or pretreated shall be prepared and placed as specified in Section A5.3. The surface of the prepared layer shall then be lightly watered until it is damp and given at least one pass with a flat wheel or steel tyre roller.

a) Applying the cementitious agent mechanically

After the layer of material has been prepared, the cementitious agent shall be spread uniformly over the full area of the layer by means of an approved type of mechanical bulk spreader at the prescribed rate of application in a continuous process.

When the mechanical application of the cementitious agent is clearly uneven in places it shall be evenly respread using squeegees where required so that it is uniformly spread over the entire surface to be stabilised before mixing may commence.

A recycler may be used to mechanically apply the cementitious agent through an on-board automatic dispensing system. Adjacent cuts of the recycler shall overlap by at least 150 mm. Over application of either moisture or cementitious agent in the overlap shall not exceed 10 % of the average requirement for the layer.

b) Applying the cementitious agent by hand

When spreading of the cementitious agent is done by hand, pockets or bags of cementitious agent shall be accurately packed out and spaced at equal intervals across the full area of the section to be stabilised so that the specified rate of application will be achieved. Spreading shall only commence once it has been confirmed by the Engineer that the correct quantity of cementitious agent has been placed on the layer by physically counting the number of pockets and checking the spacing of the pockets.

The even spreading of the hand spaced and packed cementitious agent may further be done by hand using squeegees, provided that the wind speed is less than 15 km/h (4 m/s). Irrespective of the spreading method used the cementitious agent shall be uniformly spread over the entire surface to be treated.

c) Mixing in the cementitious agent using conventional equipment

Immediately after the cementitious agent has been evenly spread, it shall be mixed with the layer material for the full depth of treatment. The completed layer underneath shall not be damaged, nor shall the cementitious agent be mixed below the required depth. Mixing shall be continued until a homogeneous mix of the material and the cementitious agent has been achieved over the full area and depth of the material being pretreated or stabilised.

Mixing shall be done using a combination of a grader, disc harrow and/or rotary mixer or by using a recycler, working over the full area and depth of the layer by means of successive passes of the construction equipment as applicable. When a recycler is used in isolation, cross-mixing is often inadequate and additional mixing plant shall then be utilised in conjunction with the recycler to ensure thorough cross-mixing. Mixing may also be done in a central batch-mixing plant if the Contractor so chooses. (Additional note: A recycler moves material laterally at most 200 mm. Assess mixing during trial section.)

After completion of the mixing process the mixed material shall be spread and shaped.

If the material is being pretreated, the shaped layer shall be given at least one pass with a flat wheel or steel tyre roller and left undisturbed for the time period as specified in Table A5.4.3-1. After the specified time period, the chemically modified layer may then be stabilised in accordance with Section A5.4 if the material is now compliant for stabilisation or processed and compacted as an unstabilised layer in accordance with Section A5.3.



Phenolphthalein test of stabilising agent application

d) Watering and mixing in of water for stabilisation using conventional equipment

Moisture content tests shall be done the day before the stabilising agent is to be added to the material in order to determine the amount of water that must be added to bring the moisture content up to the required compaction moisture content. If there is any rain after the moisture content test samples were collected additional tests shall be done.

Immediately after the cementitious agent for stabilisation has been properly mixed with the material, the required amount of compaction water shall be added incrementally. Each application of water shall be thoroughly mixed with the material before more water is added so as to avoid a concentration of water near the surface or the flow of water across the surface of the layer.

The Contractor shall ensure that a satisfactory and even moisture distribution is achieved over the full depth, width and length of the section being stabilised and shall ensure that no portion of the work gets excessively wet after the cementitious stabilising agent has been added. Any portion of the work that becomes too wet after the stabilising agent has been added and before the mixture has been compacted, due to poor construction control or disregard for the specified weather limitations or for any other specified requirement that has not been complied with, shall be rejected. Such portions shall be allowed to dry out to the required moisture content and shall then be scarified, re-stabilised using additional agent, compacted and finished off in accordance with the specification, all at no cost to the Employer.

The water supply and watering equipment shall be adequate and sufficient to ensure that all the water required shall be added and mixed with the material within a short enough period to enable compaction and finishing to be completed within the period specified in Table A5.4.3-1.

The moisture content of the material during compaction shall **never exceed 80 % of the saturation moisture content** of the natural material **without a stabilising agent. (Additional note: Be careful for too low moisture content. Water in addition to compaction is required by lime and cement.)**

The moisture content at the specified saturation degree (S_r) shall be determined as follows:

$$W_V = S_r \{X_w/X_d - 1000/G_s\}$$

W_V = moisture content of the specified degree of saturation (%)
 X_w = density of water (kg/m^3)
 X_d = dry field density of the material (kg/m^3)
 G_s = apparent density of the material (kg/m^3)
 S_r = specified degree of saturation (%).

e) Applying and mixing in the cementitious agent using a recycler (Additional note: This clause is not applicable for a BSM, which is covered in Section 5.5 clause A5.5.6.2.)

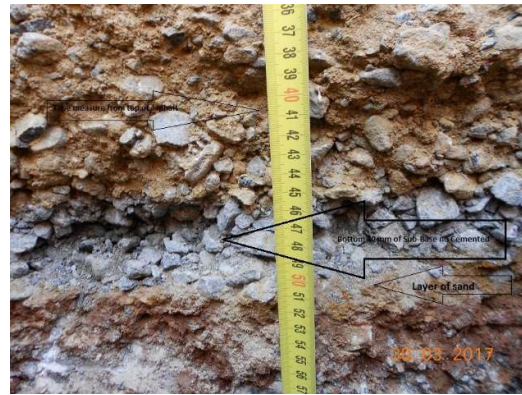
When the cementitious agent is applied by hand the requirements of Clause A5.4.7.2b) remain applicable.

The requirements of proper moisture control specified in Clause A5.4.7.2d) remain applicable.

The recycler shall be capable of applying the agent and mixing to the required depth in a single pass. The recycler shall be equipped with an on-board automatic spraying system that can accurately apply a specific metered quantity of water over the full width of the milling drum. Electronic sensors shall be fitted to maintain the milling/mixing depth within a tolerance of 5,0 mm.

The speed of rotation of the milling drum and the forward speed of the machine shall be adjustable to obtain a material that is evenly mixed with the cementitious agent. The outer edges of the recycler cut shall be vertical and the floor of the cut shall be clean and to the lines specified in the Contract Documentation. The width of application shall be the same as the cut-width of the recycler.

The recycler shall be required to simultaneously add the required amount of water and mix the cementitious agent to produce an approved uniform mix. **(Additional note: Always verify the vertical mixing of the recycler.)**



Verify recycler vertical mixing

f) Compaction of a chemically stabilised layer

Section A5.3 shall apply to the compaction of chemically stabilised layers.

During the compaction process the Contractor shall ensure that no lamination layers or biscuit layers are formed within the compacted layer. Final rolling shall be done with equipment that will give a smooth surface finish which conforms to the surface tolerances specified. Low spots on the surface of a chemically stabilised layer may not be filled after compaction.

When a recycler has been used to mix the layer material Contractor shall ensure that the mixed material between the wheel paths of the recycler is compacted to at least the same density as the material in the wheel paths, before commencing with the cutting of levels.

The minimum compaction requirements shall be as specified for the particular layer. Sufficient compaction equipment shall be employed on each layer to ensure that, from the time when the stabilising agent is first mixed into the layer, the mixing process, watering, compacting, shaping and final finishing will be completed within the time periods specified in Table A5.4.3-1.



Tamping roller marks

A5.4.7.4 Bituminous stabilisation

a) In-situ mixing for stabilisation

The material to be stabilised with bitumen shall be prepared and placed as specified in Section A5.3.

1. Addition of the cementitious agent

If a cementitious agent is specified as part of the bituminous stabilisation process then it shall be evenly spread over the layer surface (Clause A5.4.7.2) before the bitumen stabilisation process commences.

When using standard construction equipment such as a grader along with a plough / rotovator, the Contractor shall pre-mix the cementitious agent into the layer as specified (Clause A5.4.7.2) before the compaction moisture and the bituminous stabilising agent is added and mixed in.

When using a recycler, the cementitious agent shall be mixed in at the same time as the compaction moisture and the bituminous stabilising agent is being added.

(i) *Heating and diluting the bituminous stabilising agent*

The bituminous stabilising agent shall be heated to the required temperature as specified by the supplier.

If dilution of the bitumen emulsion stabilising agent with water is required, only potable water shall be used. The water shall be added gradually during constant stirring or circulation of the emulsion by means of pumps to prevent the emulsion from separating or breaking.

(ii) *Apply and mix in the bituminous stabilising agent*

The bituminous stabilising agent (foamed bitumen or bitumen emulsion) may be applied and mixed into the material using an approved in-situ recycling machine as specified in Section A5.5.

When a bituminous emulsion stabilising agent is being used it can be applied using a calibrated spray tanker with a spray bar, followed immediately behind ahead of it being mixed into the material using a grader and a rotovator.

The quantity of material being stabilised with a bituminous stabilising agent must be restricted to the amount that can be properly mixed with the available equipment before the bitumen emulsion breaks.

b) Remote mixing for stabilisation

Where in-situ mixing and stabilisation is not possible due to a confined working area or inadequate turning space for the construction equipment, then remote off-site mixing may take place.

1. Remote site and material preparation

An appropriate site shall be prepared in accord with Section A4.1 of Chapter 4 in the same way a stockpile site is specified to be prepared.

Place and spread the material on the prepared remote site to a thickness of approximately 300 mm. Place and spread the cementitious agent as specified in Clause A5.4.7.2 and proceed to mix using appropriate construction equipment such as a grader, or an articulated loader, or a rotovator.

(iii) *Adding the bituminous stabilising agent*

Apply the bituminous stabilising agent, heated and/or diluted as specified, using a hand sprayer and then mix the material further. (Additional note: Apply bitumen emulsion for remote mixing.)

Once the material has been thoroughly mixed it shall be loaded, hauled, placed and then processed at its point of use, as specified in Sections A5.3 and A5.4.

A5.4.7.5 PMPL stabilised material

Mixing of the material, water and the stabilisation agent shall be done off site at a central mixing plant. The stabilising agent content and the type of stabilising agent to be added shall be as specified in the Contract Documentation. The central mixing plant can be used to produce:

- Mixed material for a chemically stabilised gravel layer; or
- Mixed material for a chemically stabilised crushed stone layer; or
- Bitumen stabilised material (BSM); or
- Mixed material for a wet lean-mix concrete,

as specified in the Contract Documentation.

Additional note: Chemically stabilised material is seldom mixed off site in a central mixing plant and then paver laid. BSM is a better candidate for "in plant" mixing. TG2 clause 6.4 can be consulted for the mixing and laying by paver.)

The aggregate or gravel / crushed stone material and the specified type and amount of stabilising agent shall be thoroughly mixed at the mixing plant either by batch-type mixing with revolving blade or rotating-drum mixers or by the continuous-mixing process with suitable pugmill-type mixers as appropriate for the type of material being processed. The aggregate, gravel or crushed stone and the stabilising agent shall be measured by mass.

Where more than one stabilising agent has to be added to the material, the mixing plant shall contain separate hoppers for the different agents and the introduction of each of these agents into the mix shall be controlled by accurate weighing so as to ensure that the correct quantity of each agent is added consistently every time.

In all central mixing plants the water may be measured either by mass or by volume and provision shall be made for easily and accurately checking the quantity of water added per batch or checking the rate of flow of water added when use is made of a continuous mixing plant.

A5.4.7.6 Finishing at joints

This Clause A5.4.7.6 relates specifically to the construction of joints when the material is stabilised and is in addition to the specification in Clause A5.3.3.7.

Where existing works and new works are joined the material shall be mixed with the stabilising agent and compacted without causing any permeable or loose patches along the longitudinal or transverse construction joints.

Any completed portion of a stabilised layer adjacent to new work, which is used as a turn-around area by equipment in constructing the adjoining section, shall be provided with a protective cover of soil or gravel of at least 100 mm thick over a sufficient length to prevent damage to the completed work.

When the adjoining section is being finished, such cover shall be removed to permit the construction of a smooth vertical joint at the junction of the completed and adjoining section. Material in the vicinity of the joint which cannot be processed satisfactorily with normal construction equipment shall be mixed and compacted by hand or with suitable hand-operated machines.

The junctions of sections shall be finished so as to obtain an even and well-compacted joint and so as not to cause damage to the adjacent parts of any other sections.

A5.4.7.7 Protection and curing of chemically stabilised layers

All stabilised layers shall be protected against rapid drying-out for at least seven days following completion of the layer.

This can be achieved by the frequent application of water for 7 days or by water curing followed by covering with the next layer or by water curing followed by the application of an approved curing membrane. **The use of single-axle trucks with a maximum axle load of 6t shall be used to apply the chosen curing compound.**

The specific method of protection or curing used may be any one of the methods as specified hereunder or as stipulated in the Contract Documentation.

a) Water curing

The stabilised layer shall be kept **continuously wet by watering at frequent intervals for an initial period of 48 hours** after the compaction of the stabilised layer has been completed. **The stabilised layer shall thereafter be kept continuously damp for at least a further five days.**

Any stabilised layer which is not kept continuously wet or damp for at least seven (7) days, and is by default therefore subjected to consecutive wet-dry cycles, may be rejected if the layer exhibits shrinkage cracking or any carbonation.

b) Damp protective layer curing

The stabilised layer shall **first be cured for 48 hours** as specified in Clause A5.4.7.7a).

The stabilised layer shall then be **covered** with the material required for the next layer. The covering material shall be **placed using only single-axle trucks with a maximum axle load of 6t** and then **immediately spreading** the material. The layer material shall **not be compacted**. Water curing of the still **exposed portions of the stabilised layer shall continue** while the curing layer is dumped and spread.

The material forming the spread layer shall be watered at such intervals as may be required to keep the stabilised layer continuously damp until it has been **cured for at least 7 days**. In dry weather the spread layer shall be well watered at least once every 24 hours and even more often in hot or windy weather conditions.

c) Membrane curing

The chemically stabilised layer shall be covered with a curing membrane consisting of spray-grade bitumen emulsion or cutback bitumen applied at the rate specified in the Contract Documentation immediately after stabilisation.

d) Prime coat curing

Where a prime coat is specified on top of any stabilised layer, the prime coat may be utilized as a curing membrane and it shall be applied at the rate specified in the Contract Documentation. Use of the prime coat as a curing membrane may only be applied provided the surface moisture is only slightly damp and not wet.

If the prime coat is utilised as a curing membrane for a stabilised base layer, payment shall only be made once for the prime coat and no additional payment will be made for providing a curing membrane.

e) Curing of PMPL layers

PMPL chemically stabilised gravel and PMPL chemically stabilised crushed stone layers shall be cured using one of the methods as specified in this Clause A5.4.7.6a) to d).

PMPL wet lean-mix concrete layers shall be cured using a concrete curing membrane which shall be sprayed onto the lean-mix concrete layer at the rate of application specified by the supplier as soon as the initial concrete set has occurred.

A5.4.8 WORKMANSHIP

A5.4.8.1 Inspection of the works

The Engineer shall do routine inspections and conduct routine tests to determine whether the quality of material and workmanship provided, complies with the requirements of the Contract Documentation.

Any stabilised layers with lamination layers such as biscuit layers, as identified visually and/or by the hollow sound caused when a heavy chain is dragged over the stabilised layer, shall be rejected.

The material in the rejected sections of the completed layer shall be ripped and removed and replaced with new material. The new material shall then be stabilised and compacted according to the specifications prior to the construction of any subsequent layers.

Alternatively, the material in the rejected sections can be recycled in-situ with an additional quantity of stabilising agent as determined by testing and instructed by the Engineer. In-situ recycling will only be permitted provided that the properties of the recycled material are compliant with the specified requirements for that layer of material.

All remedial work shall be carried out at no cost to the Employer.

A5.4.8.2 Material properties

The test results and measurements of the material quality, compaction density, stabiliser content and the engineering properties of the stabilised layers shall be assessed in accordance with the provisions of Chapter 20.

A5.4.8.3 Quality/process control

It shall be the responsibility of the Contractor to ensure that the Engineer has been informed in writing of the daily testing requirements. The material testing can then be properly co-ordinated and completed timeously.

Sample preparation and testing for checking and approving the properties of chemically stabilised material shall be done as per the approved SANS test methods.

Sample preparation and testing for checking and approving the properties of bituminous stabilised material shall be done as specified in Section A5.5.

The stabilised material sampled from the layer for the compaction of MDD briquettes shall be prepared according to SANS 3001-GR50 and compacted according to SANS 3001-GR31.

A5.4.8.4 Tolerances

a) Rates of application

1. Chemical stabilisation

The average rate of application of a cementitious stabilising agent when applied by mechanical bulk spreading equipment and measured by the canvas patch method shall be within 5 % of the specified rate of application over any section not exceeding 1,0 km in length. No single measurement shall deviate by more than 20 % from the specified rate.

When hand placed and spread, or spotted, stabilising agents shall be spread exactly to the specified rate of application.

The rate of application of the cementitious stabilising agents added to the material in a central mixing plant shall be controlled by means of weighing the stabilising agent before it is introduced into the mixing plant.

2. Bituminous stabilisation

The rate of application of the bituminous stabilising agent shall be within 5 % of the specified rate in the Contract Documentation.

b) Uniformity of cementitious stabilisation

The quantity of cementitious binder in the mixed material as determined during sampling and testing as specified in Chapter 20, shall be within the limits specified in the statistical judgement plan described in Chapter 20 using the following formula;

(S_n / X_n) where;

S_n = the standard deviation of stabiliser

X_n = the average stabiliser content

Where required by the Engineer, the Contractor shall determine the mix uniformity of chemically stabilised layers by means of indirect tensile strength tests, using SANS 3001-GR54. Samples for the determination of the uniformity of the mix shall be taken immediately after the material has been mixed with the water and stabiliser and spread, but before the layer is compacted. The Contractor shall therefore make the necessary arrangements timeously and allow for the time to collect the samples.

As described in Chapter 20, test results shall be adjusted to make allowance for the presence in the material being stabilised of minerals, which affect the test results. The above requirements for uniformity of mix shall be applied only on condition that the variation in these adjustments falls within the limits specified in Chapter 20. The coefficient of variation may not exceed 0,3 or 30 % for material mixed in-situ, and 0,2 or 20 % for material mixed in a central mixing plant.

C5.4 STABILISATION

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the constructional plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Items not measured in this Section

The following required activities will not be measured or paid for separately and the Contractor shall include the cost thereof in other items as deemed appropriate:

1. All surveying, setting out and level control required for the stabilisation of the pavement layers.
2. Protection of all existing or new kerbs, channels, sidewalks, lined drains, catch pits, kerb inlets, gratings, culverts, bridges, structures, buildings, road signs, guard rails, street lights, fencing, service pipes or cables and any other items adjacent to, over or under the road to prevent damage by any stabilising agent.
3. Repair of all damage to surfacing and any new or existing structures, buildings and road furniture caused by the stabilising agents.
4. All setting out work required for the accurate application of the stabilising agent specified in the Contract Documentation.

(iii) Items to be measured and paid for using items specified elsewhere in the specifications

For activities in Table C5.4-1 items specified in other Chapters or Sections of the specification, where they relate to work under this Section, will be listed in the Pricing Schedule.

Table C5.4-1: Payment items from other Chapters or Sections

Activity	Section 5.4 reference	Section item reference
Clearing and grubbing - remote mixing	A5.4.7.4b)	Section C1.6 of Chapter 1 – All applicable items
Construction of stockpile site - remote mixing	A5.4.7.4b)	Section C4.1 of Chapter 4 – All applicable items
Procurement of stabilising agents	A5.4.5	Section C4.4 of Chapter 4 – All applicable items
Procurement of commercial materials	A5.4.5.1	Section C4.4 of Chapter 4 – All applicable items
Reclaimed materials	A5.4.5.1	Section C5.5 – All applicable items
Processing and compaction of layer material	A5.4.7	Section C5.3 – All applicable items
Curing – membrane or prime	A5.4.7.6c) / A5.4.7.6d)	Section C6.1 of Chapter 6 and Chapter 10 – All applicable items

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C5.4.1	Pretreatment of gravel layers (Additional note: new item.)	
C5.4.1.1	Pre-treatment of (insert layer thickness) gravel layer	cubic metres (m ³)
C5.4.1.2	Pre-treatment of (insert layer thickness) gravel layer using labour enhanced methods of construction	cubic metres (m ³)

The unit of measurement shall be the cubic metre of pre-treated material, the quantity of which shall be determined in accordance with the authorised compacted dimensions of the layer being treated.

No distinction be made in respect of the type of treatment agent used, the time taken for completion, or the specific layer being treated. The rate tendered shall furthermore apply to any combination of agents. Delivering the agent to the point of use and the distinction in respect of the manner in which the stabilising agent is spread, whether it be by hand using bags or by mechanical bulk spreader shall be paid under item C5.4.5.

The tendered rates shall include full compensation for watering and compacting the surface of the placed material prior to spreading the pretreatment agent for mixing the specified amount of pre-treatment agent, for the addition of any water required, and all materials, supervision, labour, equipment, tools and incidentals necessary for completing the specified work including for leaving the layer dormant for a period of 24 hours after being treated.

Distinction shall also be made in respect of the method of mixing and construction of the layer, either using mechanical methods of construction or using labour enhancement methods. The layer thickness can be varied by up to 20 mm and the rate for this pre-treatment work shall remain applicable.

Item	Description	Unit
C5.4.2	Chemical stabilisation	
C5.4.2.1	Chemical stabilisation (layer thickness indicated) of pavement layers (layer to be stabilised indicated)	cubic metres (m ³)
C5.4.2.2	Chemical stabilisation (layer thickness indicated) of pavement layers (layer to be stabilised indicated) using labour enhanced methods of construction	cubic metres (m ³)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the compacted chemically stabilised layers

No distinction shall be made in respect of the type of treatment agent used, the time taken for completion, or the specific layer being treated. The rate tendered shall furthermore apply to any combination of agents. Delivering the agent to the point of use and the distinction in respect of the manner in which the stabilising agent is spread, whether it be by hand using bags or by mechanical bulk spreader shall be paid under Item C5.4.5.

The tendered rates shall include full compensation for watering and compacting the surface of the placed material prior to spreading the stabilising agent, for the mixing of the specified amount of stabilising agent and all materials, supervision, labour, equipment, tools and incidentals necessary for completing the specified work. No distinction shall be made in respect of the type of cementitious stabilising agent used or the time for completion or the specific layer being stabilised. Distinction shall be made in respect of the method of mixing and construction of the layer, either using mechanical methods of construction or using labour enhancement methods. The layer thickness can be varied by up to 20 mm and the rate for this chemical stabilisation work shall remain applicable.

Item	Description	Unit
C5.4.3	Stabilised crushed stone PMPL layer (pavement layer, type of material and source indicated)	cubic metre (m³)

The unit of measurement shall be the cubic metre of stabilised material for the PMPL layer, the quantity of which shall be calculated in accordance with the authorised dimensions of the final layer.

The tendered rate shall include full compensation for mixing the specified amount of stabilising agent at the central mixing plant and all materials, supervision, labour, equipment, tools and incidentals necessary for completing the specified work. No distinction will be made in respect of the type of cementitious stabilisation agent used, the time for completion or the specific layer being treated.

Item	Description	Unit
C5.4.4	Wet lean-mix concrete pavement PMPL layer (indicate specific pavement layer):	cubic metres (m³)

The unit of measurement shall be the cubic metre of wet lean-mix concrete for the PMPL layer, the quantity of which shall be calculated in accordance with the authorised dimensions of the final layer.

The tendered rate shall include full compensation for mixing the specified amount of cementitious agent, water and material at a mixing plant (PMPL) and all materials, supervision, labour, equipment, tools and incidentals necessary for completing the specified work. No distinction will be made in respect of the type of cementitious stabilisation agent used, the time for completion or the specific layer being treated.

Item	Description	Unit
C5.4.5	Cementitious stabilisation agents for pavement layers (Additional note: new item.)	
C5.4.5.1	Addition of cementitious stabilisation agents (specify agent separately) for pavement layers	
(a)	Cement (for pavement layer)	ton (t)
(b)	And so forth for other agents (for pavement layers)	ton (t)
C5.4.5.2	Addition of cementitious stabilisation agents (specify agent separately) for pavement layers and spreading the agent using bags and labour enhancement methods.	
(a)	Cement (for pavement layer)	ton (t)
(b)	And so forth for other agents (for pavement layers)	ton (t)

The unit of measurement shall be the ton of cementitious stabilising agent spread and mixed into the prepared layer material in-situ.

The tendered rates shall include full compensation for the **supply and delivery of the agent to the point of use**. The tendered rates shall also include for spreading the specified amount of cementitious stabilising agent, and all materials, supervision, labour, equipment, tools and incidentals necessary for completing the specified work. The layer thickness can be varied by up to 20 mm and the rate for this work shall remain applicable.

A distinction shall be made between spreading the cementitious soil stabilisation agents by mechanical bulk spreaders or using labour enhancement methods.

(Additional note: There are 3 related pay items for chemical stabilisation:

1. Item C4.4.4 – for procuring, transporting and delivering the stabilising agent to the site, either next to the road or to a storage shed. No distinction is made for providing the stabilising agent in bulk or in pockets.

2. Item C5.4.5 – for supply and delivery of the stabilising agent from the delivery point, either from next to the road or from the shed, to the point of use on the road and for spreading the agent. Item C5.4.5.1 for spreading by tankers, and item C5.4.5.2 for spreading using pockets.

3. Item C5.4.2 – for mixing the stabilising agent with the material.

Item	Description	Unit
C5.4.6	Addition of cementitious stabilisation agents (specify agent separately) for a PMPL layer	
C5.4.6.1	Cement	ton (t)
C5.4.6.2	And so forth for other agents	ton (t)

The unit of measurement shall be the ton of cementitious stabilising agent mixed into the material at a central mixing plant at the specified application rate.

The tendered rates shall include full compensation for delivery of the agent from storage to the mixing plant and introducing the specified amount of cementitious agent and water into the mixing plant for the PMPL layer and all materials, supervision, labour, equipment, tools and incidentals necessary for completing the specified work. No distinction shall be made in respect of the type of cementitious stabilisation agent used, the time for completion or the specific layer being produced whether that is a wet lean-mix concrete or a chemically stabilised crushed stone material.

Item	Description	Unit
C5.4.7	Bituminous stabilisation of pavement layers	cubic metres (m³)
C5.4.8.1	Bituminous stabilisation (layer thickness indicated) of pavement layers (layer to be indicated)	litres (ℓ)
C5.4.8.2	Bituminous stabilisation (layer thickness indicated) of pavement layers (layer to be indicated) using labour enhanced methods of construction	litres (ℓ)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the bituminous stabilised compacted layer.

The tendered rates for bituminous stabilisation shall include full compensation for watering and compacting the surface of the placed material prior to spreading the stabilising agent, for mixing the specified amount of stabilisation agent and material and shall include full compensation for all incidentals. No distinction shall be made with regard to the type of bituminous stabiliser used, the time for completion, and the particular layer to be stabilised with bitumen. The tendered rate shall apply to any combination thereof.

The layer thickness can be varied by up to 20 mm, and the rate for this cementitious stabilisation work shall remain applicable.

A distinction shall be made between spreading the cementitious soil stabilisation agents by mechanical bulk spreaders or using labour enhancement methods.

Item	Description	Unit
C5.4.8	Bituminous stabilisation agent (specify agents separately)	
C5.4.8.1	60 % anionic emulsion	litres (ℓ)
C5.4.8.2	60 % cationic emulsion	litres (ℓ)
C5.4.8.3	Foamed bitumen	litres (ℓ)
C5.4.8.4	Any other	litres (ℓ)

The unit of measurement shall be the litre of bituminous stabilising agent mixed into the road layer at the specified application rate. For bitumen emulsion this shall be the litre of 60 % emulsion mixed into the material. For foamed bitumen this shall be the litre of bitumen that is foamed.

For bitumen emulsion stabilisation the tendered rates shall include full compensation for diluting and introducing the specified amount of stabilisation agent at the point of use, and shall include full compensation for all incidentals. No distinction shall be made in regard to the type of bituminous stabiliser used, the method of application, the time for completion, and the particular layer to be stabilised with bitumen and the tendered rates shall apply to any combination thereof. The layer thickness can be varied by up to 20 mm, and the rate for this bituminous stabilisation work shall remain applicable.

For foamed bitumen, the rate shall also include for foaming the bitumen on the recycler, including the water and any other additive that may be required to achieve the minimum foaming characteristics and for injecting the foamed bitumen into the material being processed

The tendered rates shall also include full compensation for heating and the transfer into tankers of the bitumen. It shall also include for coupling to the recycling train, for all transport on site, for any re-heating required, for all wastage and for strict adherence to all safety measures required when handling warm or hot bitumen.

Item	Description	Unit
C5.4.9	Filler for bituminous stabilisation	
C5.4.9.1	Filler for bituminous stabilisation (specify agents separately)	ton (t)
C5.4.9.2	Filler for bituminous stabilisation spreading the agent or filler using labour enhanced methods of construction (specify agents separately)	ton (t)

The unit of measurement shall be the ton of cementitious agent mixed into the road layer at the specified application rate.

The tendered rates shall include full compensation for the supply and the blending of the specified amount of filler with the bituminous stabilisation process and all materials, supervision, labour, equipment, tools and incidentals necessary for completing the specified work. No distinction will be made in respect of the type of filler used, the time for completion or the specific layer being treated.

A distinction shall be made between spreading the filler by mechanical bulk spreaders and using labour enhancement methods.

(Additional note: There are 5 related pay items for bituminous stabilisation:

1. Item **C4.4.5** – for procuring, transporting and delivering the bituminous agents to the site, for transfer into storage tanks and heating as required.
2. Item **C4.4.6** – for procuring and transporting the filler to the site, and for storing.
3. Item **C5.4.8** – for preparing the bituminous agent: Diluting the emulsion and foaming the bitumen.
4. Item **C5.4.9** – for supply (from storage) and blending (spreading and pre-mixing when not applied by recycler) the filler.
5. Item **C5.4.7** – for mixing the stabilising agent, and filler when using a recycler, with the material.)

Item	Description	Unit
C5.4.10	Provision and application of water for curing	kilolitre (kℓ)

The unit of measurement shall be the kilolitre of water provided and applied for curing a chemically stabilised layer.

The tendered rate shall include full compensation for furnishing, transporting and applying the water.

Item	Description	Unit
C5.4.11	Curing by covering with the subsequent layer	square metre (m²)

The unit of measurement shall be the square metre of chemically stabilised pavement layer being cured by covering it with the subsequent layer. The quantity will be determined by the plan area of the authorised dimensions of the layer being cured

The tendered rate shall include full compensation for incidentals in respect of applying the subsequent layer for curing as specified, including the cost of regularly supplying and applying water.

Item	Description	Unit
C5.4.12	Curing with a membrane (type of material to be specified)	
C5.4.12.1	Cut back bitumen	litre (ℓ)
C5.4.12.2	Inverted bitumen emulsion	litre (ℓ)
C5.4.12.3	Spray grade emulsion	litre (ℓ)
C5.4.12.4	Curing compound for PMPL layers	litre (ℓ)

The unit of measurement shall be the litre of curing material measured at spraying temperature and sprayed as specified.

The tendered rates shall include full compensation for supplying the material, preparation of the surface before applying the curing membrane, applying the membrane material and maintaining the surface as specified.

Item	Description	Unit
C5.4.13	Trial section for a PMPL layer (specify width)	square metre (m²)

The unit of measurement for the trial section of the plant-mixed paver-laid pavement layer shall be the square metre of trial section of the specified width as specified in the Contract Documentation measured along the centre line of the road. A total length of at least 250m of trial section and no more than 350 m will be measured for payment as a trial section.

The tendered rate shall include full compensation for supplying, introducing and mixing the cementitious stabilising agent at the specified rate at the mixing plant for the construction of the trial section.

Item	Description	Unit
C5.4.14	Trial section for a chemically stabilised layer	cubic metre (m³)

The unit of measurement for the trial section of a chemically stabilised pavement layer shall be the cubic metre of trial section as per the authorised dimensions. A total length of at least 150 m of trial section and no more than 200 m will be measured for payment as a trial section.

The tendered rate shall include full compensation for placing spreading and mixing the stabilising agent at the specified application rate during the construction of the trial section.

Item	Description	Unit
C5.4.15	Trial section for a bituminously stabilised layer (specify width)	square metre (m²)

The unit of measurement for the trial section of a bituminously stabilised pavement layer shall be the square metre of trial section of the specified width as specified in the Contract Documentation measured along the centre line of the road. A total length of at least 250 m of trial section and no more than 350 m will be measured for payment as a trial section.

The tendered rate shall include full compensation for placing spreading and mixing the bituminous stabilising agent and filler at the specified application rate during the construction of the trial section.

Item	Description	Unit
C5.4.16	Mechanical modification	cubic metre (m³)

The unit of measurement shall be the cubic metre of material in the compacted layer which has been mechanically modified as per Clause A5.4.7.2a) calculated using the layer work dimensions given in the Contract Documentation.

The tendered rate shall include full compensation for mixing all the different materials together to form one homogeneous layer as per Clause A5.4.7.2.

Payment for the construction operations required to process and compact the modified layer shall be made under item C5.3.2.

Item	Description	Unit
C5.4.17	Addition of a soil binder	cubic metre (m ³)

The unit of measurement shall be the cubic metre of soil binder added to and mixed into the pavement layer as per Clause A5.4.7.2b). The volume of soil binder shall be calculated using the completed layer work dimensions given in the Contract Documentation multiplied by the percentage by volume of soil binder added as specified.

The tendered rate shall include full compensation for mixing the soil binder into the layer to form one homogeneous layer.

Payment for the construction operations required to process and compact the modified layer shall be made under item C5.3.2

QUESTIONS?

BREAK!

2.7. Section 5.5 – Reconstruction of pavement layers

5.5 RECONSTRUCTION OF PAVEMENT LAYERS

CONTENTS

PART A: SPECIFICATIONS

- A5.5.1 SCOPE
- A5.5.2 DEFINITIONS
- A5.5.3 GENERAL
- A5.5.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS
- A5.5.5 MATERIALS
- A5.5.6 CONSTRUCTION EQUIPMENT
- A5.5.7 EXECUTION OF THE WORKS
- A5.5.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

A5.5 RECONSTRUCTION OF PAVEMENT LAYERS

PART A: SPECIFICATIONS

A5.5.1 SCOPE

This Section covers the work requirements for the **reconstruction of existing road pavement layers**. This comprises **patching and in-situ reconstruction**.

A5.5.1.1 Patching

Patching covers the work requirements for the patching of existing pavement layers, and in exceptional cases patching fills and the roadbed, with the purpose of repairing local failures. Patching involves excavating the existing failed sections to the specified depth and area, removing the excavated material and reconstructing the excavated fills and pavement layers with the specified material.

Patching specified in this **Section A5.5** is applicable when the **project scope of works is predominantly the reconstruction of Pavement Layers**.

Patching specified in **Section A8.8** is applicable when the **project scope of works is predominantly the construction of Asphalt Layers**.

This scope also covers the work requirements for the repair of edge breaks.

Resurfacing the repaired failed area does not form part of this scope and is provided for in Chapters 8 and 9.

A5.5.1.2 In-situ reconstruction

In-situ reconstruction covers the work requirements for the process using either conventional construction equipment exclusively or a custom-designed recycling machine (recycler) along with some conventional construction equipment, to reconstruct pavement layers.

A5.5.2 DEFINITIONS

The relevant definitions in the standard specification are applicable. Additional definitions for this Section are included here.

Conventional equipment - this is equipment that is normally used for the construction of the Works. This equipment excludes equipment specifically designed and used for in-situ reconstruction works and/or for the recycling of materials.

Cross-mixing - this is the mixing of layer materials horizontally across a layer width when the material properties of the layer are not the same throughout the width and the depth of the layer. Cross-mixing cannot be carried out using a recycler.

Edge break - an edge break is a defect in which the outer edge of the wearing course and part of the underlying pavement layer (asphalt or crushed stone or gravel) is broken and/or worn away resulting in an irregular road edge line with an average defect width of 250 mm or less. Edge breaks wider than 250 mm are defined as patching.

In-situ - this means in the actual original or final location without moving the material elsewhere.

Patching - means the repair of failures in fill and/or pavement layers when the failed **width is less than 1,0 m** or the failed **length is less than 25 m** or the failed **area is less than 100 m²**. Patching does not include the pretreatment of a surfacing, or the repair/patching of surfacing defects, or the rehabilitation of a concrete pavement which is covered in Chapters 8 (pretreatment), 8 (surface defects) or 7 (repair of concrete).

Reconstruction - this is the reconstruction of existing pavement layer material (in-situ or reclaimed material) with or without stabilisation.

Reconstruction in several construction phases can be accomplished using conventional construction equipment to reclaim and reconstruct layer work material or in a single construction phase using a recycler along with some conventional construction equipment to achieve the reclaiming and reconstruction of layer work material.

Rehabilitation - this is the restoration of an existing deteriorated or failed road pavement either to the original constructed condition or to a better condition. The restoration of the road pavement can take place by patching, by layer reconstruction, by adding layers or a combination of the aforementioned as specified in the Contract Documentation.

Recording pass - this is the roller-pass when the roller's compactometer readings are recorded, cross-referenced to a location and compared with the specified layer density requirements. A recording pass is only made on the second roller-pass over the same area. **A recording pass comprises two passes with the roller.** (Additional note: A recording pass is different from the roller pass definitions in A5.1.2.)

Slushing - the process of wetting the surface of a compacted layer accompanied by rolling with a smooth-drum roller and/or a pneumatic tyre roller to generate saturated fine material or slush, on the upper surface of the compacted layer.

Uniform pavement section - a uniform pavement section has pavement layers with similar layer materials, similar layer properties, similar layer thicknesses and similar deflection responses (when available) throughout the section. Uniform pavement sections shall be clearly identified in the Contract Documentation.

A5.5.3 GENERAL

A5.5.3.1 Traffic accommodation

The traffic accommodation arrangements required during the reconstruction of existing roadworks in urban and rural areas are specified in Chapter 1 of the specifications. (Additional note: In Section 1.5)

The works-specific details shall be specified in the Contract Documentation.

A5.5.3.2 Material selection

The reclaimed material specifications in this Section are supplementary to the material specifications of Chapter 4. Reclaimed material from existing pavements shall be utilised as specified in the Contract Documentation.

All reclaimed material from existing pavements, or reconstructed in-situ, shall be broken down and oversize material removed, to comply with the maximum size and grading requirements for the particular use of the reclaimed material as specified in the Contract Documentation.

The classes of excavation for reclaimed material shall be as specified in Section A4.3 of Chapter 4.

A5.5.3.2 Construction requirements

The processing, compaction, stabilisation, finishing and protection requirements of the in-situ material or reclaimed material as specified in Sections A5.1 to A5.5 shall apply to the construction of reclaimed material and to the reconstruction of in-situ pavement layers.

In addition, the processing and compaction of materials for patching shall also be carried out as specified in the relevant Sections of Chapter 5.

A5.5.3.3 Existing bituminous seal and/or asphalt layers

Thin **bituminous seal surfacing layers** are usually processed together with the underlying pavement layer or layers which are being reclaimed or reconstructed in-situ, unless the complete removal thereof is specified in the Contract Documentation. (Additional note: Measurement and payment for removal in item C4.3.3.)

Asphalt surfacing and/or asphalt base layers may be reclaimed by **milling** off to stockpile as specified in Clauses A4.3.7.4 to A4.3.7.6 or they may be reconstructed in-situ, together with the underlying pavement layer(s). (Additional note: Milling execution in A4.3.7 and payment in items C4.3.6 and C4.3.7.)

Bituminous seal surfacing or asphalt base and/or surfacing layers which are processed together with the underlying gravel or crushed stone pavement layer/s shall be properly broken down by the milling and reconstruction process and mixed thoroughly with the underlying material and to the depth as specified in the Contract Documentation. Any remaining fragments of the bituminous seal surfacing or asphalt material which exceed the specified maximum particle size of the pavement layer being reprocessed shall be broken down or removed as oversize material.

A5.5.3.4 Reconstructing existing pavement layer materials

Where the existing pavement material is to be reconstructed in-situ as base, the exposed surface shall be cleaned by removing all remaining fragments of asphalt material. No more than 15 % of the exposed surface area shall still be covered but with a reduced thickness of no more than 10 mm of asphalt material.

The existing pavement material shall be broken down to the full depth and then reconstructed in-situ, as specified in the Contract Documentation

A5.5.3.5 In-situ reconstruction near existing road infrastructure

Care shall be exercised to avoid damage to any concrete elements, expansion joints, joint nosings, manholes, kerbing, catch pits and any other roadside furniture during reconstruction of the layers. Damage caused to any element forming part of the permanent works shall be repaired at no cost to the Employer.

A5.5.3.6 Exposed pavement layer

The exposed surface of the in-situ layer left after a pavement layer has been excavated, shall be inspected once the exposed surface has been cleaned of all loose material by sweeping, or blowing with compressed air or by vacuuming.

Irrespective of whether the exposed layer is an unstabilised layer or a stabilised layer the **cleaned floor of the excavation shall be inspected for any failed areas and for cracks of any form by the Contractor along with the Engineer.** (Additional note: Refer clause A5.5.7.3 for identification of cracks.)

A5.5.3.7 Widening an existing pavement

Where existing roads need to be widened, the existing pavement layers shall be cut back to a firm, well-compacted or cemented material ahead of

the commencement of any widening activities. The cut back material may be used together with imported material in the widening process as specified in the Contract Documentation.

Where pavement layers are widened, then the different existing pavement layers shall be excavated in steps or benches as specified in Clause A5.3.3.7.

If there is a restricted working space caused by the widening of an existing pavement over a narrow width, the Contractor shall ensure that all material complies with the specified maximum aggregate sizes before the material is brought into the restricted working space. No further breaking down on the road shall be permitted within the restricted working space unless the Contractor can demonstrate that the oversize material can be broken down or removed successfully without compromising the safety of workers or members of the public using the adjacent road.

A5.5.3.8 Programme of reconstruction work

All reconstruction work shall only take place in accordance with the accepted reconstruction programme which the Contractor shall compile and submit to the Engineer prior to commencing the reconstruction of each uniform road pavement section. The programme shall be regularly updated and submitted to the Engineer at the end of each week.

Prior to the start of each single-operation of work, the Contractor shall prepare a M&U plan detailing proposals for the work. This plan shall at least include the following:

- The overall layout of the length and width of road intended to be reconstructed during the single-operation. The width shall be divided into the number of parallel cuts (for a recycler) or width of construction (for conventional equipment) required to achieve the specified overall width of reconstruction.
- The location of overlaps and the overlap width (minimum overlap of 150 mm) at each longitudinal joint between adjacent cuts/widths.
- The location of the inner and outer wheel paths of each construction lane affected by the reconstruction.
- The sequence and length of each cut/width to be reconstructed before starting on the adjacent or following cut/width.
- An estimate of the time required for the reconstruction along each cut/width and for finishing off the work.

A5.5.3.9 Contractor M&U plans for the reconstruction of layerworks

The Contractor shall prepare and submit a management and utilisation (M&U) plan for the reconstruction of existing layerworks to ensure that it is worked in a sustainable and sensitive manner, to ensure that the environmental impact is minimised, that material use and haulage are optimised and that the work is carried out in a cost-effective manner. **Every reconstructed layer in each uniform section shall require a M&U plan to be submitted. The Engineer can approve that a representative M&U plan be submitted for the reconstruction of layers where the material type, road particulars such as road width, traffic accommodation and reconstruction methods only differ slightly.**

The M&U plan shall at least take cognizance of the following and provide detail of the following as appropriate:

- The intended traffic accommodation methodology and phasing.
- The pavement layer patching programme.
- A method statement and programme for the reconstruction of each of the pavement layers including the reclaiming of existing road materials, the breaking down and processing in-situ of an existing pavement layer and the completion of each layer.
- Details of the programme for the movement of materials to ensure that the material is not handled unnecessarily.
- The survey methods to be used to set out and control the levels and width of the pavement layers for each processed layer.
- A method statement for the construction of a trial section using a recycler and/or using conventional equipment as applicable.
- A method statement of how oversize material will be dealt with.
- Measures to comply with the general and specific conditions of the road environmental management plan.
- Measures to comply with safety regulations and obligations in terms of the relevant Health and Safety Acts and Regulations.
- The full quality and process control testing detail for the applicable materials tests along with the frequency and quantity of such testing for each constructed section of each layer to ensure full compliance of the constructed layer in terms of compaction density, material quality and stabilisation testing (visual and laboratory), and
- Procedure for the regular monitoring, auditing and reporting.

M&U plans need to be submitted during the course of construction. The Contractor's construction programme shall set out by when each M&U plan will be submitted for review. The reconstruction of a particular layer shall only commence once the Contractor's M-&U plan for that layer and uniform section has been reviewed and accepted by the Engineer. The Engineer shall respond within one week after receiving an M&U plan.

A5.5.4 DESIGN BY THE CONTRACTOR / PERFORMANCE BASED SYSTEMS

The Contractor shall be permitted to submit an alternative individual layer design and/or alternative pavement design.

The predicted pavement life for any alternative design submission shall be the same expected life as that of the original pavement design in the Contract Documentation.

A5.5.5 MATERIALS

The Contractor shall ensure that reclaimed material complies with the specified requirements of Chapter 4 prior to use in the particular pavement layer.

Further specifications for patching of existing road pavement layers and for the processing and compaction of existing road pavement layer materials using a recycler, are contained in this Section A5.5.

A5.5.5.1 Existing crushed stone pavement materials

Where existing crushed stone material is to be reconstructed, the Contract Documentation shall specify whether the material shall be processed as a gravel layer or as a crushed stone layer.

The compaction requirements specified in Table A5.3.5-2 shall apply to crushed stone layers constructed from reclaimed or in-situ reconstructed material unless specified otherwise in the Contract Documentation.

A5.5.5.2 Stockpiling reclaimed asphalt and reclaimed pavement material

Stockpile sites for reclaimed asphalt and reclaimed pavement materials shall be constructed as specified in Clauses A4.1.7.3a) of Chapter 4. When asphalt material is reclaimed and stockpiled for reconstruction, the surface of the stockpile area shall also be constructed as specified in Clauses A4.3.7.12a) of Chapter 4.

Reclaimed asphalt (RA) from the same uniform source shall be stockpiled as per Clause A4.1.7.3b) of Chapter 4 in the same stockpile and in immediately adjacent stockpiles, when a new stockpile is commenced. The requirements in this Clause A5.5.5.2 are in addition to those in Clauses A4.1.7.3b) and A4.3.7.12b) of Chapter 4.

Each **stockpile of reclaimed asphalt (RA)** shall be constructed in such a manner that will restrict segregation and compaction of the stockpiled material as follows:

- Each stockpile shall not exceed 1000 t.
- The stockpile shall not exceed a height of 2,5 m to prevent consolidation of the RA.
- The RA stockpile shall be located on the sloping stockpile site so that the water drains away from the loading end.
- The stockpile shall be shaped so that water drains off the top and down the stockpile side slopes.
- Side slopes shall not be steeper than 1 vertical(V) : 2 horizontal(H).
- The loads of RA shall be dumped uniformly over the entire RA stockpile area.
- A light bulldozer or front-end loader shall then doze the material into a ramp-shaped stockpile, in layers.
- Travel on the stockpile by heavy equipment such as the front-end loader or the light bulldozer shall be minimized.
- Trucks shall not travel on the stockpile.

Reclaimed gravel or reclaimed crushed stone material from the same uniform sources shall be stockpiled as per Clause A4.1.7.3b) of Chapter 4 in the same stockpile and in immediately adjacent stockpiles, when a new stockpile is commenced. The requirements in this Clause A5.5.5.2 are in addition to those in Clauses A4.1.7.3b) and A4.3.7.12b) of Chapter 4.

Each **stockpile of reclaimed pavement materials** shall be constructed in such a manner that will restrict segregation and compaction of the stockpiled material as follows:

- Each stockpile of reclaimed material shall not exceed a height of 3,0 m.
- Side slopes shall not be steeper than 1V:2H.
- The loads of reclaimed material shall be dumped uniformly over the entire material stockpile area.
- A light bulldozer or front-end loader shall then doze the material into a stockpile in layers.
- The reclaimed material shall be placed in layers no more than 1,0 m thick. Each layer shall be completed and levelled prior to placing the next layer.
- The layers shall be constructed horizontally or constructed at a maximum slope of 1V:3H.
- Trucks shall not travel on the stockpile.

After the stockpiled material has been removed the stockpile site(s) shall be reinstated as per Clause A4.1.7.3c).

A5.5.5.3 Imported materials for patching

The imported materials used for patching shall comply with the material specifications of Section A4.1 of Chapter 4 for the specific layer being reconstructed in the patch.

A5.5.5.4 Compaction density

The density of the reconstructed layer shall be measured in terms of the MDD of the layer.

The minimum compaction density for reconstructed pavement layers shall be as specified in Table A5.5.5-1.

Table A5.5.5-1: Minimum compaction density for reconstructed material

Reconstructed material type	Compaction as % of maximum dry density (MDD)	
	Cementitious stabilisation	Bituminous stabilisation
Natural gravel	as per Table A5.3.5-1	100
Graded crushed stone	as per Table A5.3.5-2	102

A5.5.5.5 Material shortfall and make-up material

Where there is a shortfall of material for the reconstruction of a layer or layers, this shortfall shall be imported from compliant material prepared in accord with the specification in Chapter 4 from stockpile or from commercial sources as specified in the Contract Documentation. The shortfall of material may be due to the poor shape of the road pavement or due to poor levels or to a deficient as-built layer thickness.

The grading and other properties of the in-situ material blended with the imported material shall be determined. Where the grading of this layer to be reconstructed is not compliant either in-situ, or after being milled, or after being ripped and broken down, then make-up material shall be imported and blended with the in-situ material so that the combined grading and other material properties of the in-situ reconstructed layer shall be as specified.

Nowhere shall the thickness of imported material exceed two thirds of the depth of reconstruction. **(Additional note: The layer will then be classified as new construction.)**

A5.5.6 CONSTRUCTION EQUIPMENT

Construction equipment to carry out the rehabilitation or reconstruction of existing layer work material shall comply with the requirements of Clause A1.2.6 of Chapter 1, Section A4.3 of Chapter 4 and Clause A5.4.6.

When a recycler is used as part of the layer processing operation, this construction equipment must be capable of mixing and placing the material in a single pass, to line, level and cross-fall.

A5.5.6.1 Construction equipment for patching

All construction equipment shall be suitable for the specific use and size of working area and be capable of completing all the specified construction work within the construction tolerances.

The Contractor shall prepare the list of construction equipment required for the type and extent of patching for the specific project. The following types of construction equipment are typically required for patching:

- Pedestrian and small ride-on roller.
- Vibratory plate compactor.
- Mobile compressor with matched paving breakers.
- Mechanical saw and hand tools.
- Hand-operated compactor.
- Mobile concrete mixer.
- Tractor loader backhoe (TLB) or small front-end loader.

A5.5.6.2 Construction equipment for in-situ reconstruction

All in-situ reconstruction shall be done using conventional construction equipment or using a custom-designed recycling machine hereinafter referred to as a recycler.

These requirements are specific and are in addition to conventional construction equipment requirements specified elsewhere in Clause A1.2.6 of Chapter 1 and Clause A5.4.6.

a) Recycler

(i) Recycler performance

The recycler shall comply with the following requirements:

- The recycler shall have sufficient power to break down and mix the existing pavement material while pushing or pulling bulk supply tankers.
- Have a level-control system which is capable of maintaining the cut depth within a tolerance of 10 mm of the specified depth during continuous operation.
- The cutter shall have a minimum cut width of 2.0 m with the capability to change the speed of rotation and forward movement. The machine shall be capable of reconstruction to the specified depth in a single pass. Maximum depth capability of the recycler shall be 0.4 m.
- The maximum speed of advance recommended by the manufacturer of the particular recycler shall be provided by the Contractor for acceptance. A maximum speed of advance of 10 m/min shall not be exceeded.

(ii) Recycler liquid application

The liquid application system of the recycler shall comply with the following requirements:

- A liquid application system dedicated to adding water to the material in the mixing chamber shall be fitted.
- Where a bituminous stabilising agent is to be applied, a second separate liquid application system shall be fitted to add the stabilising agent to the material in the mixing chamber. The system shall be appropriate for the addition of either bitumen emulsion or foamed bitumen as required.
- The application systems shall be controlled by a micro-processor / flow meter combination that can accurately regulate pump delivery or flow rate in accordance with the speed of advance of the recycler and the volume of material being processed.
- All liquid application systems shall include a dedicated spray bar that spans the full width of the mixing chamber. Each spray bar shall be equipped with multiple injection nozzles mounted equidistant along the length of the bar at a maximum interval of 200 mm with the ability to close off selected nozzles, thereby allowing the required width of application to be set.
- Where two liquid application systems are used, the water application spray bar shall be mounted ahead of the other spray bar (relative to the direction of rotation of the cutter) such that the material encounters the water spray before encountering the stabilising agent.

The liquid application system shall also have the following specific features installed on the recycler, for foamed bitumen:

- Each injection nozzle on the spray bar fitted with an expansion chamber capable of adequately foaming the bitumen.
- Gauges installed on the bitumen supply line for monitoring the bitumen temperature and pressure.
- A feature to demonstrate that all expansion chambers are free of blockages in both the water and bitumen feed lines.
- A test nozzle to provide a representative sample of foamed bitumen at any stage during normal operations.
- A micro-processor that shall continuously monitor the actual bitumen consumption whilst working and provide a continuous accumulative total that allows immediate reconciliation with the theoretical consumption required to meet the specified nett bitumen application rate.

(iii) Mixed material placement by the recycler and subsequent compaction

The recycler shall be capable of breaking down the material to the specified depth in the layer or layers of the existing pavement and then blending that material together with additional material as and when required, with a stabilising agent, with water and any other specified agents or additives. The machine shall be capable of breaking down the material and of achieving the required blend and consistency of mix in a single pass.

The in-situ material mixed by the recycler and then levelled and placed behind the recycler, shall be compacted using suitable compaction equipment and graders to construct a layer that meets the specified requirements.

Sufficient construction equipment shall be utilised to enable the stabilised material to be processed and finished within the time limitations specified in Table A5.4.3-1.

b) Milling machine Additional note: Milling machine requirements in A4.3.6.2.)

When the Contractor intends to use construction equipment such as a track-mounted milling machine to pulverise the existing layer material in-situ, followed by the use of conventional construction equipment to further process the pulverised material, comprehensive details of the alternative construction equipment shall be submitted for review and acceptance.

When a milling machine is only used to pulverise the existing material, followed by conventional construction equipment to process the pulverised material, this conventional construction equipment shall be capable of mixing the required material with the stabilising agents and produce a uniform mix consistency.

The basic requirements for a milling machine are given in Clause A4.3.6.2 of Chapter 4.

c) Spreaders for applying filler

Where filler is spread on the road surface using a mechanical spreader, the low spread rate required when applying $\leq 1\%$ by mass requires a special type of spreader.

Special units that utilise a cellular wheel for metering the powder can accurately apply rates as low as 0.7% and are, therefore, ideal for spreading active filler on a reconstruction project utilising bitumen stabilisation.

d) Heavy duty motor grader

A heavy duty motor grader (minimum 120 kW and minimum 14 ton) is an essential item of plant. The grader is required to pre-shape the material prior to treatment, for processing the material and to cut final levels once all the material processing is complete.

Grader processing includes mixing the material prior to treatment and mixing in the filler and bitumen emulsion. Depending on the volume of material being mixed and the quantity to be treated in a single shift, more than one grader may be required.

e) Water tanker

Self-propelled water tankers with a minimum capacity of 15 000 litres are essential.

Water tankers involved with bitumen emulsion stabilised materials shall only ever transport diluted emulsion. Each water tanker must be equipped with a circulating pump system to circulate the emulsion after standing for two days and before each water tank spray. These water tanks shall not be equipped with a spraybar but with a concave dish located beneath a vertical outlet pipe. The emulsion must be released by opening an audco-type valve immediately above the concave dish. The shape of the concave dish will ensure a widespread spray distribution of emulsion.

This is a cold application process of emulsion.

f) Compaction equipment

The primary compaction rollers shall be selected by the Contractor to suit the material type and layer thickness being compacted and to achieve the specified density requirements. A primary compaction roller may be a single drum vibrating roller. A padfoot drum is normally fitted to the primary roller when the layer thickness exceeds 150 mm. A pneumatic-tyred roller (PTR) may be used along with a padfoot primary roller as the primary compaction roller combination when processing fine material. A padfoot roller along with a smooth drum roller may be used as the primary compaction rollers to compact a coarse material.

Table A5.5.6-1: Primary roller: Recommended static mass

Layer thickness (mm)	Static mass (ton)
< 150	12
150 - 200	15
200 - 300	20
300 - 350	25

The secondary compaction rollers shall be selected by the Contractor for finishing the surface of the layer such as a suitable smooth-drum vibratory roller and/or a PTR or in combination.. A single or tandem smooth drum roller may be used. The rollers shall be used to compact the upper portion of the layer and to produce a well-knit, smooth surface finish.

A 20 ton PTR as a finishing roller may work well once the grader has completed cutting the layer to level and cross-fall, to achieve a tightly-knit surface finish.

A trial section shall be constructed to resolve the best roller combinations for the primary rollers, the secondary rollers and the finishing rollers.

g) Static storage tanks and bulk tankers

Bulk tankers with sufficient capacity to match the production rate of the recycler shall be used to supply the recycler "on the move" with water and liquid stabilising agents.

Static tanks used for the storage and supply of bituminous stabilising agents to the recycler and/or to conventional construction equipment shall be equipped with a circulating pump system. The stored emulsion shall be properly circulated every 2 days. A thermometer to measure the temperature of the bitumen in both the top and bottom halves of the supply tank must be installed in the static tank.

A5.5.7 EXECUTION OF THE WORKS

A5.5.7.1 Patching

The excavation and backfilling of all patching work, complete as specified for a patch, shall be carried out and completed on the same day when under traffic. When the portion of road being patched is temporarily closed to all traffic, the patch excluding the wearing course, shall still be completed on the same day unless specified otherwise.

The applicable specifications in Chapters 4 and 5 shall be applicable to the construction of each layer to be processed as part of a patch repair.

a) Patch demarcation

The Contractor shall be responsible for accommodating the traffic in accordance with the specified requirements during the demarcation work.

Areas to be patched shall be demarcated on site by the Contractor in conjunction with the Engineer. The Contract Documentation shall specify the various types of patching expected to be done for the various failed areas of the road section. Each demarcated area shall be cross-referenced to one of the repair types.

The Contractor shall give at least 4 calendar days notice to the Engineer of the intention to commence with repair work of any nature on any specific section of the road, so that there is sufficient time to demarcate the areas to be patched.

b) Excavating existing pavement material

All excavations for patching shall have a neat rectangular shape. The existing material shall be excavated and removed to the full specified depth. Asphalt surfacing layers shall be saw-cut along the patch perimeter before any excavation work may commence.

The sides of the excavation for patching shall be cut vertically (by saw-cutting or using pneumatic tools) through each existing layer with a maximum allowable horizontal deviation from the vertical, of 6V:1H which is equivalent to 25 mm horizontal deviation for each 150 mm excavated layer depth. The saw-cut location for each successive layer shall be moved horizontally by 150 mm to ultimately create stepped layers around the perimeter of the patch excavation.

Excavation may also be done using a milling machine when appropriate.

Excavated material from each pavement layer shall be placed in separate stockpiles adjacent to the patch. The stockpiled material shall be re-used or spoiled as specified.

The floor of the excavation shall be compacted in-situ, if the layer density is not compliant with the specified density for that particular layer.

After completion of the patch excavation to the specified depth, the Engineer shall inspect the excavation prior to it being backfilled.

c) Backfilling patch excavations

Excavations shall be backfilled with compliant pavement material for each layer as detailed in the Contract Documentation. The excavated material shall be used when compliant or compliant material shall be imported. The backfilling shall be compacted to the specified density and finished to the required levels for each layer. The base layer shall be finished to line and level to allow for the correct thickness of surfacing specified.

The Contractor shall place, mix and evenly spread the backfilling material into the patch excavation in individual layers and then compact each layer to the specified density. The layers shall only be as thick as will successfully be compacted by the construction equipment being used. The layer thickness shall not be less than twice the nominal maximum aggregate size in the backfilling material.

Where chemical stabilisation is specified the stabilising agent shall be added and mixed into the backfilling material in accordance with the applicable specifications in Section A5.4.

Where emulsion treated base is specified for the base layer of the patch, the mix shall comply with Clause A4.1.5.15 of Chapter 4. The compliant base material shall be placed in a concrete mixer or similar and mixed with water and a suitably diluted emulsion to achieve the required compaction moisture content. Cement shall then be added while the mixing continues. Mixing shall continue until a uniform mix of the base material, the bitumen emulsion and the cement is obtained.

Where asphalt base or bituminous surfacing material is specified as the wearing course for the completed patch, the preparation, mix design and placement specification in Chapter 8 and / or Chapter 9 shall be applicable.

Use of a concrete mix or a soil cement mix to backfill a patch excavation shall not be permitted.

The level tolerances for patches are specified in Clause A5.5.8.3.

A5.5.7.2 Edge break repairs

This treatment shall be used for finishing off or repairing the edges of the surfaced area of a road. The repair is carried out so that the edges of the repaired areas line up with the true edge of the original road surface or a newly surveyed edge as specified in the Contract Documentation.

Edge breaks shall be repaired in accordance with the patching specification in Clause A5.5.7.1 and as specified in the Contract Documentation.

Where asphalt base or bituminous surfacing material is specified as the wearing course for the completed edge break repair, the preparation, mix design and placement specification in Chapter 8 and / or Chapter 9 shall be applicable.

A5.5.7.3 Treatment of exposed pavement layer

Where a pavement layer is excavated and removed using a milling machine or conventional construction equipment, the in-situ layer below shall be inspected.

The cleaned surface shall be lightly sprayed with water to identify cracks. As the sprayed surface starts to dry, cracks dry out last making them visible. The inspection shall take place by the Contractor along with the Engineer.

The Contract Documentation shall specify what treatment is required for exposed stabilised pavement layers and unstabilised pavement layers.

a) Stabilised exposed layer

All repairs shall be demarcated and carried out as specified.

Cracks shall be sealed as instructed by the Engineer and as specified in Sections A8.5 and A8.6 of Chapter 8.

Failed areas not caused by negligence on the part of the Contractor, shall be measured and paid for as a patch in accord with the size parameters for a patch.

If the failed area is too large to be classified as a patch, it shall be measured and paid for as the reconstruction of a stabilised in-situ layer. Reconstruction of the stabilised layer shall be carried out as per the applicable Clauses of A5.5.7.

Failed areas caused by negligence on the part of the Contractor during the excavation of the layer that was above shall be repaired by the Contractor at no cost to the Employer.

Where specified, the application of a prime coat shall be carried out as specified in Section A8.1 of Chapter 8.

b) Unstabilised exposed layer

Where the exposed layer is unstabilised, the layer shall be inspected to establish the soundness of the layer. Any settlement cracks such as a longitudinal crack shall be repaired by reconstruction of the layer in the vicinity of the crack or as instructed by the Engineer.

Material testing of the exposed layer such as in-situ density and CBR strength shall be carried out when instructed by the Engineer.

Failed areas not caused by negligence on the part of the Contractor, shall be measured and paid for as a patch in accord with the size parameters for a patch.

If the failed area is too large to be classified as a patch, it shall be measured and paid for as the reconstruction of an unstabilised in-situ layer. Reconstruction of the unstabilised layer shall be carried out as per the applicable Clauses of A5.5.7 or it can be compacted using roller-pass compaction.

Failed areas caused by negligence on the part of the Contractor during the excavation of the layer that was above shall be repaired by the Contractor at no cost to the Employer.

A5.5.7.4 In-situ pavement layer reconstruction preparation (Additional note: Seven important activities listed in this clause.

Uniform pavement sections shall be clearly identified and detailed in the Contract Documentation.

In accord with these uniform sections an existing gravel layer or existing crushed stone layer may be reconstructed in-situ using a recycler or using conventional construction equipment.

The preparation for the in-situ reconstruction, irrespective of the type of construction equipment used, shall be as specified in Clause A5.5.7.4a) to g).

a) Establishing construction levels – minor level changes

Before commencing any in-situ reconstruction, the Contractor shall establish reference and level beacons for the setting-out and control of the works.

When only **minor level changes (less than 15 mm up or down)** will be made to the existing vertical alignment and/or to the road cross-fall or camber, in order to restore the riding quality of the road, then new road design levels will not usually be provided in the Contract Documentation.

At each level control location, the **Contractor shall record the existing road surface levels** at the centre-line and at the outer limits of each lane including any surfaced shoulders. The **Contractor shall use the existing road levels to determine the new construction levels** along the centreline and the outer limits of each traffic lane and any surfaced shoulders. **A line of best fit** shall be used to determine the final levels for the reconstructed layer taking into account the following:

- Minimising the amount of preparatory work required ahead of reconstruction, such as minimising the importation of material.
- Additional in-situ existing pavement material investigation
- The required design camber as specified in the Contract Documentation.
- The minimum cross-fall of 2 %.
- The minimum requirements governing changes in the vertical alignment.
- The thickness of the existing layer to be reconstructed.

At least two calendar weeks before reconstruction work is programmed (programme compiled in accord with Section A1.2 of Chapter 1) to commence on any specific uniform pavement section, the Contractor shall submit the level proposals to the Engineer in sufficient detail to enable the proposed reconstruction levels to be reviewed. The detail shall incorporate a schedule as well as a drawing, of all the design levels and the grade lines. Once agreement has been reached regarding the proposed levels, reconstruction work may commence.

The Contractor shall establish a series of level control poles placed at a constant offset on both sides of the road prior to commencing any construction work at a maximum interval as specified in Table A5.3.8-2. The Engineer shall take control measurements to determine the accuracy and adequacy of the level control poles and shall instruct the Contractor to make any adjustments as required.

b) Establishing construction levels – significant level changes

When significant level changes **(more than 15 mm up or down)** will be made to the vertical alignment and/or to the road cross-fall or camber, the reconstructed layers shall be **reconstructed to new design levels provided in the Contract Documentation**.

Before commencing any in-situ reconstruction, the Contractor shall establish reference and level beacons for the setting-out and control of the works.

The Contractor shall survey the existing road levels and compare these with the new design levels and prepare a schedule of the areas where there will be surplus material and of the areas where there will be insufficient material. This schedule will be used to prepare a layer material transfer diagram which will enable the transfer of surplus reconstructed material to areas where there is a shortage of material. The material transfer diagram shall be submitted to the Engineer for review at least two calendar weeks before reconstruction work is programmed (programme compiled in accord with Section A1.2 of Chapter 1) to commence on any specific uniform pavement section.

The Engineer shall subsequently instruct the Contractor regarding the proposed reuse or spoil of surplus material, or the need to import any additional new material prior to the commencement of the reconstruction work.

The Contractor shall establish a series of level control poles placed at a constant offset on both sides of the road prior to commencing any construction work at a maximum interval as indicated in Table A5.3.8-2. The Engineer shall take control measurements to determine the accuracy and adequacy of the level control poles and shall instruct the Contractor to make any adjustments as required.

c) Pre-milling the seal or asphalt surfacing

This construction work shall only be done using a milling machine.

Where specified in the Contract Documentation, pre-milling ahead of reconstruction shall be undertaken to remove isolated high spots or make level adjustments more than 10 mm, normally at crest vertical curves, by accurate milling. The material resulting from such milling operations shall be directly loaded onto trucks and disposed of as specified in the Contract Documentation.

d) Preparation of the road surface

Before any reconstruction work may commence, the surface of the existing road shall be prepared as follows:

- Remove all vegetation, dirt and other foreign matter including from any adjacent lanes or shoulders that are not to be reconstructed.
- Remove road studs from the full road width.
- Remove standing water.
- Establish an off-set reference line, for each cut, for the recycler to follow and ensure accurate steering.
- Record the location of all road marking features that will be obliterated by reconstruction.
- Rip and then grade off the asphalt or bituminous seal surfacing and take to spoil or stockpile as specified in the Contract Documentation using conventional construction equipment.
- Use a milling machine to mill off the asphalt or bituminous seal surfacing and take to spoil or stockpile as specified in the Contract Documentation.
- A bituminous seal may be left in place where specified in the Contract Documentation.

e) Pre-pulverising existing pavement layer material

Pre-pulverising or breaking down existing pavement material shall only be undertaken where specified in the Contract Documentation by ripping or by using a milling machine or a recycler. Pre-pulverising shall be carried out to accomplish one or more of the following:

- Breaking down hard material prior to further processing with the recycler.
- Loosening the material across the road width so that it can be cross-mixed.
- To enable layer levels to be adjusted and/or to correct a road that is badly out of shape both in cross-section and long-section before reconstructing/recycling the layer.
- The material in the existing pavement can be loaded and removed for direct use elsewhere or removed to stockpile or removed to spoil where specified in the Contract Documentation. The exposed layer beneath may then be reconstructed in-situ where specified in the Contract Documentation.
- To enable the removal of surplus material from areas where the vertical alignment is being lowered or the removal of material to spoil or to stockpile prior to the commencement of the reconstruction operation.

The depth of pre-pulverising shall ensure that the cut horizon always remains at least 20 mm above the top of the pavement layer below which is not being reconstructed and that this underlying pavement layer remains undisturbed.

Cross-mixing of the pre-pulverised material may be specified in the Contract Documentation or instructed by the Engineer.

The pre-pulverised material shall after shaping, be compacted to a minimum density of 93% MDD ahead of the in-situ pavement layer reconstruction when using a recycler and shall receive one roller-pass using a smooth drum roller when using conventional construction equipment.

f) Addition of imported material or make-up material

Imported material as specified in Clause A5.5.5.5 shall be spread on the pre-pulverised existing pavement layer prior to cross mixing and subsequent reconstruction when required.

The placing and spreading of the imported material shall be such as to achieve the required reconstructed layer thickness and design levels for the specific layer.

The compliant mixed existing and imported material shall be shaped and pre-compacted prior to the commencement of any reconstruction. This ensures a firm surface for the recycler and the other equipment connected to the recycler to travel on.

g) Final preparations for the in-situ reconstruction process

No reconstruction work shall commence until the Contractor has confirmed that all the reconstruction construction equipment is in good working order and is available alongside the particular section, to be reconstructed.

Where applicable the stabilisation mix design shall have been completed, and the types of agent and application rates thereof confirmed by the Engineer to the Contractor. Sufficient quantities of the stabilising agents shall also be on the site. Where the cementitious agent is applied mechanically or by hand on the reconstruction cut width, this shall be carried out as specified in Clause A5.4.7.

The following temperatures shall be measured and recorded to ensure compliance with the temperature-related specifications:

- Ambient air temperature.
- The temperature of the material in the reconstruction horizon.
- The temperatures of the bulk bitumen, the bitumen emulsion and the water in the respective tankers.

A5.5.7.5 In-situ pavement layer reconstruction

a) Final recycler construction equipment checks

The recycler shall be prepared for the first reconstruction cut. This shall include checking that:

- The mixing chamber is free of any material build-up that may reduce the efficiency of the cutting and remixing operation and that can affect the functioning of the application nozzles on all relevant spray bars.
- The cutting drum is free of any material build-up that can reduce the efficiency of the cutting and remixing operation.
- The cutting tools are new or evenly worn across and around the cutting drum with sufficient remaining life to complete the first cut without stopping.
- All relevant liquid application systems are functioning, free of blockages and that the in-line filters are clean. Where a bitumen stabilising agent is applied, the check-sheet as provided in the Contract Documentation shall be completed and submitted to the Engineer.
- The on-board computer has been correctly set up and that the input data has been verified.

- The spray bar is set up with the correct nozzles selected to achieve the required width of application and in the case of further cuts the nozzles across the 150 mm construction joint overlap are closed to prevent over-application of water and/or bituminous stabilisation agents.
- An off-set reference line is in place for the recycler to follow and is correctly aligned relative to the final road geometry.
- The depth of recycling has been confirmed and that all the equipment has been properly set to achieve this depth.

Where the **primary compaction equipment** is equipped with an integrated compactometer system it shall be checked to establish whether it is working and that it has been set to record and print the correct data.

The **bulk supply tanker/s** shall be checked to ensure that they are coupled correctly to the recycler. Where stabilising agents are spread by hand on the road surface ahead of the recycler it shall be carried out as specified in Section A5.4.

All **feed pipes** shall be properly connected, bled of air and free of leaks. In the case of bituminous stabilising work, the feed pipe shall only be connected immediately before this work is about to start. Where the stabilising agent is foamed bitumen, the outlet pipes and valves on the bitumen tanker shall be checked and any blockages cleaned out before connecting the feed pipe.

b) In-situ reconstruction using a recycler (Additional note: Also consult TG2 Clause 6.2.)

The maximum allowable speed of advance of the recycler shall be 10 m per minute. The speed of advance of the recycler and the speed of rotation of the recycling drum, shall be regulated to achieve:

- Adequate pulverisation of all bound materials in the existing pavement to produce a material that complies with the grading specification.
- Adequate mixing of all components to produce a homogenous material.
- A uniform and continuous application rate of liquid stabilising agent(s) and water at the specified application rates across the full width of treatment.

(i) Layer dimensions

The depth of reconstruction shall coincide with the line and level specified for the lower horizon of the reconstructed stabilised layer. The bottom of the cut horizon shall be checked at least once every 20 m of travel using a suitable T-bar to measure down from a string line pulled between the final level reference marks on the level control posts.

An overlap width of 200 mm shall be maintained along all the longitudinal joints. The longitudinal line of cut shall not deviate laterally by more than 50 mm from the operator's off-set reference line that shall be positioned and then re-positioned for each and every cut.

(ii) Mixing and placing the material

The mixing process shall be continuous with a minimum number of stops. Transverse joints that occur each time the recycler stops, shall be properly treated to achieve continuity of stabilisation agent and moisture content across the joint.

The temperature across the entire width of material exiting the mixing chamber shall be checked every 100 m using a digital laser thermometer held no more than 100 mm above the mixed material. Where the temperature varies by more than 3°C along a particular longitudinal strip 200 mm wide, the recycler shall be stopped and the application nozzles on all the relevant spray bars and nozzles that coincide with the deviant strip shall be checked for blockages.

As the mixed material exits from behind the recycler it shall be struck off by the rear door of the mixing chamber with sufficient pressure applied onto the mixed material, to obtain a uniform surface that is free of valley lines, empty pockets and particle segregation.

(iii) Primary compaction of the reconstructed material

A recycler is configured such that the rear wheels travel on top of the treated material along the outer extremities of the reconstruction cut. Under no circumstances shall the reconstructed material be pre-shaped by grader prior to being compacted. To prevent differential compaction across the width of the reconstruction cut, initial rolling to level the material between the recycler wheel tracks shall be carried out with a recording pass of a steel drum roller in static mode (no vibration) and hence no compactometer readings or any other readings are taken during this recording pass. Then the primary compaction process shall commence.

The primary compaction shall follow at the same rate of advancement as the recycler. Single vibrating smooth-drum rollers and/or pad foot rollers shall be utilised to compact the reconstructed material. The rollers shall travel forwards and backwards at a constant speed not exceeding 50 m per minute or 3 km/h, all the while remaining within the confines of the reconstructed cut.

Reconstructed material spilling over the outer extremities of the cut shall be cleared at regular intervals of about 5,0 m to expose the cut line, thereby guiding the roller operator(s) to remain within the reconstructed cut width.

Successive lengths of mixed material, each approximately 50 m shall be compacted at a time. Rolling shall continue on each 50 m section until the maximum achievable density has been reached. Where an integrated compactometer device is utilised, rolling shall continue until the device indicates that no further improvement of density is occurring over at least 80 % of the length of the section. The maximum achievable density has then been reached over at least 80 % of the section. Should the device indicate a consistent loss of density at any one location, as indicated over two successive recording passes during primary compaction, compaction on that section shall be terminated and the roller moved forward to start compaction of the next 50 m section.

To prevent differential compaction across the width of any reconstruction cut, primary compaction shall be completed prior to any grader work commencing. A grader shall be used after completion of the primary compaction operation to cut the material down to level. Sufficient reconstructed material depth shall be mixed and placed to ensure that there will be no low spots needing to be built up during the cutting of levels. All low spots shall be reconstructed to the full depth of the reconstructed layer at no cost to the Employer.

(iv) Secondary compaction and final levels

After completing the primary compaction on all adjacent cuts that make up the total width of pavement as reconstructed in a single-operation, the surface shall be shaped and cut to level before secondary compaction is commenced. The moisture in the layer shall be controlled during this process by applying light applications of water sprayed onto the exposed surfaces. No roller shall be allowed onto the layer during this shaping process to prevent any lamination layers or biscuit layers from forming.

Secondary compaction comprising a minimum of three roller-passes shall then be commenced, using suitable smooth-drum vibrating and/or pneumatic tyre rollers. Additional water may need to be sprayed onto the surface during this secondary compaction operation in order to achieve a tight, well-knit surface finish. The smooth-drum rollers shall only operate in low amplitude vibration mode.

Reconstructed material now flattened over the outer extremities of the cut shall be cleared at regular intervals of about 5,0 m to expose the cut line, thereby guiding the roller operator(s) to remain within the reconstructed cut width.

(v) Slushing the reconstructed layer using water (Additional note: This slushing only for finishing and very different from the slush-compaction of a G1 crushed stone.)

When the secondary compaction and the cutting to level of the reconstructed layer is complete, the surface shall be slushed.

When no bitumen stabilising agent has been used in the reconstructed layer along with the chemical stabilising agent the slushing shall commence by spraying the surface with water. Each spray of water shall be sufficient to completely wet the compacted surface but without the water flowing off the surface of the compacted layer.

A pneumatic tyre roller shall then roll the wet surface in short sections between 40 m and 60 m long over the full width of the reconstructed layer. The pneumatic tyre roller shall make sufficient passes and the surface must be sufficiently wet to generate a small amount of fines in the form of slush and simultaneously close up small voids in the surface, close all grader-induced defects and achieve a tightly knit surface finish without any biscuit layers.

Rolling with the pneumatic tyre roller shall continue until no free water is visible and a visually uniform surface appearance is achieved. Hand held brooms or squeegees shall then move the slush over areas showing signs of roughness and/or segregation. The squeegees or brooms shall be used to remove any surplus slush to the edge of the road surface. While still damp, the slush shall be broomed, loaded and hauled to a designated spoil site at no cost to the Employer.

If a mechanically powered broom is used the surface shall not be damaged or loosened during the brooming process. The slushing process must be completed on the same day that the stabilisation and reconstruction work is commenced.

Traffic shall not be permitted over the reconstructed layer.

Where the reconstructed layer is the base layer the final surfacing shall be placed prior to opening the road to traffic. The end product of the slushing process is dependent on the material properties and therefore the desired surface finish must be established during the construction of a trial section using the same material.

(vi) Slushing the reconstructed layer using bitumen emulsion

When the secondary compaction and the cutting to level of the reconstructed layer is complete, the surface shall be slushed.

When a bitumen stabilising agent has been used with or without a chemical stabilising agent in the reconstructed layer the slushing shall commence by spraying the surface with bitumen emulsion.

A diluted bitumen emulsion at 15 % residual bitumen shall be applied at a rate of application between 0,5 l/m² and 0,75 l/m² for the first application or as instructed by the Engineer. A water tanker fitted with an appropriate spraying system or a binder distributor shall be used to spray a uniform amount of dilute emulsion on the surface before commencing with any rolling with a pneumatic tyre roller. The first application and subsequent applications of bitumen emulsion shall be applied so as not to flow off the surface being slushed. The amount of bitumen emulsion to be sprayed shall be confirmed during the construction of a trial section. Additional diluted emulsion shall be applied until sufficient slush is generated under the wheels of the pneumatic tyre roller but before the emulsion starts to break.

A pneumatic tyre roller shall be used to slush the wet surface. This shall be undertaken in short sections between 40 m and 60 m long over the full width of the reconstructed layer. The pneumatic tyre roller shall make sufficient passes and the surface shall be sufficiently wet to generate a small amount of fines in the form of slush and simultaneously close up small voids in the surface, close all grader-induced defects and achieve a tightly-knit surface finish without any biscuit layers. Rolling should continue until a visually uniform appearance is achieved. Rolling shall cease at the first indication that the emulsion shows of breaking and adhering to the tyres of the roller.

Hand held squeegees or brooms shall continuously move the slush over areas showing signs of roughness and/or segregation. The squeegees or brooms shall be used to remove any surplus slush to the edge of the road surface. While still damp, the slush shall be broomed, loaded and hauled to a designated spoil site at no cost to the Employer.

If a mechanically powered broom is used the surface shall not be damaged or loosened during the brooming process. The slushing process must be completed on the same day that the stabilisation and reconstruction work is commenced.

The end product of the slushing process is dependent on the material properties and therefore the desired surface finish must be established during the construction of a trial section using the same material.

Traffic shall not normally be permitted over the reconstructed layer and the final surfacing shall preferably be placed prior to opening the road to traffic. Where the intention is to open the finished layer to early trafficking the section of road shall remain closed to traffic for a minimum period of 24 hours after completion. The moisture content of the layer shall also be checked after 24 hours and provided it is below 80 % of OMC, the new layer may be opened to traffic when instructed by the Engineer.

Until a subsequent additional pavement layer or the surfacing is applied, the Contractor shall maintain the surface integrity of the reconstructed layer. Maintenance personnel shall inspect all sections under traffic on a daily basis and take immediate action as soon as any sign of surface ravelling is detected. Such action shall include the local application of dilute emulsion applied by hand using a large paint brush, the application of a fog spray or patching with bituminous slurry or asphalt as appropriate.

c) In situ reconstruction using conventional construction equipment (Additional note: Also consult TG2 clause 6.3)

The exposed in-situ gravel layer or crushed stone layer shall be scarified to the full depth of the existing layer or to the depth as specified in the Contract Documentation when pre-pulverising has not been carried out. The scarified material shall then be broken down and all oversize material removed. Excess material shall be loaded and removed for direct use elsewhere or removed to stockpile or to spoil.

Suitable material may also be added as specified in Clauses A5.5.5.5 and A5.5.7.3f).

All required stabilisation of the broken down material shall be done as specified in Clause A5.4.7.

The Contractor shall then process the layer in-situ as specified for pavement layers in Clause A5.3.7.

Slushing of the reconstructed layer shall be carried out as specified in Clause A5.5.7.5b), (v) and (vi).

A5.5.7.6 Reconstruction trial section

The Contractor shall construct an in-situ reconstruction trial section for each uniform section of pavement using the approved mix design determined in accordance with the specifications in Clause A4.4.7 of Chapter 4. The uniform sections shall be as specified in the Contract Documentation.

The Engineer may waive the need for a trial section for each uniform section, when the approved mix design and material types are similar for each uniform section.

The Contractor shall follow the in-situ reconstruction process specified in Clause A5.5.7.3.

Prior to constructing the reconstruction trial section the Contractor shall assemble all items of construction equipment proposed to be used for the trial section. Only the construction equipment items (conventional or recycler) that the Contractor intends using for production work shall be used to construct the trial section and under no circumstances shall any substitutes be permitted.

The objectives of the trial section are as follows:

- To demonstrate that the construction equipment and the proposed process will enable the construction of the reconstructed layer in accordance with the specified requirements in the Contract Documentation.
- To determine the effect on the grading of the reconstructed material by varying the advance speed of the recycler and the rate of rotation of the milling drum.
- To determine how many roller-passes are required to achieve the specified relative compaction density.
- To confirm the finishing process methodology and confirm the required surface finish standard.
- To check the surface regularity of the base layer for compliance with Clause A5.3.8.5a).
- To determine the bulking factor of the reconstructed material, the size of the working windrow and the amount of material to be removed after construction

A trial section shall be at least 150 m in length with a maximum of 200 m in length and shall cover the full lane width or partial road width in accordance with the geometry of the road and the accepted work plan.

If the Contractor makes any alterations in the methods, processes, equipment or materials used, or is unable to consistently comply with the specifications due to variations in the in-situ material or for any other reason, the construction of another trial section shall be required. If the first trial section proves to be non-compliant a second trial section shall be constructed. The non-compliant first trial section shall be at no cost to the Employer.

Reconstruction work may only commence once a trial section has been evaluated and certified compliant for a particular uniform pavement section. Thereafter, it is the responsibility of the Contractor to obtain the necessary approval for the relevant mix design and any alterations to the mix design that may be necessary for each uniform section ahead of the commencement of the reconstruction work.

To allow sufficient time to assess all aspects of the quality of the completed trial section and to ensure that the test results are compliant, the Contractor shall programme to start the in-situ reconstruction work no sooner than 7 calendar days after constructing the trial section. The Contractor shall have no claim for any programme delay caused by the construction of trial sections for whatever reason and the time required to construct, test and approve the trial sections shall be allowed for in the approved construction programme.

A5.5.7.7 Curing reconstructed layers

The **curing of chemically stabilised layers** shall take place as specified in Clause A5.4.7.

No curing treatment is required for a **bitumen stabilised layer** when the layer has been slushed with a diluted bitumen emulsion.

A5.5.8 WORKMANSHIP

A5.5.8.1 Inspection of the works

The Engineer shall do routine inspections and conduct routine tests to determine whether the quality of material and workmanship provided, complies with the requirements of the Contract Documentation.

Any reconstructed layer with lamination layers or biscuit layers, as identified by the hollow sound caused when a heavy chain is dragged over the compacted layer or when the layer is tapped with a geological hammer shall be rejected. The material in the rejected sections of the completed layer shall be reconstructed in accord with the specifications or in accord with instruction from the Engineer. The layer shall be reconstructed prior to the construction of any subsequent layers at no cost to the Employer.

A5.5.8.2 Material quality and compaction requirements

The test results and measurements will be assessed in accordance with the provisions of Chapter 20: Quality Assurance.

A5.5.8.3 Construction tolerances for pavement layers

The individual reconstructed pavement layers shall comply with the construction tolerances for the appropriate layer as specified in Clause A5.3.8.4. The surface regularity of a reconstructed base layer shall comply with the requirements of Clause A5.3.8.5a).

When a pavement layer of material is processed directly on top of a milled excavation floor (Clause A5.5.3.6), without the requirement that the milled excavated floor first be trimmed to prescribed levels, the thickness tolerances shall not apply to the processed pavement layer on top provided the compacted thickness of the layer on top is not less than 130 mm thick.

The final surface on any particular point on patches or between the patch and existing surface shall not deviate more than 5,0 mm from the bottom of a 3,0 m long straight edge. The surface of the base layer of the patch shall match this tolerance taking into account that the maximum deviation shall be 5,0 mm plus the proposed surfacing thickness.

A5.5.8.4 Material testing for reconstructed layer

Sample preparation and testing for bitumen stabilisation sampling and testing shall be in accordance with the latest edition of TG2.

The stabilised material sampled from the layer for the compaction of MDD briquettes, shall be prepared according to SANS 3001-GR54 and compacted according to SANS 3001-GR31.

A5.5.8.5 Reconstructed layer process control (Additional note: Only required when using a recycler and for BSM construction.)

The Contractor shall establish a comprehensive process control system for the reconstruction work. This shall consist of a system of daily reports submitted to the Engineer.

a) Pre-reconstruction report

This report shall comprise the following:

- The production and cut plans.
- The completed pre-start check list.
- Weather conditions and temperature measurements.

b) Post-reconstruction report

This report shall comprise the details of the reconstruction work completed during a single-operation with the following information for each reconstruction cut (for a recycler) or reconstruction width (for conventional construction equipment):

- Start and end km value.
- Width and depth of cut including a schedule of dip measurements.
- Width of application of each stabilising agent.
- Nozzle settings and closures for each relevant spray bar.
- Computer data input.
- Number of primary compaction recording passes made.
- Primary compaction process control density records.
- Compaction data (including compactometer reading, vibration amplitude, advance speed of roller) in electronic format from the integrated compactometer device fitted to the primary roller when applicable, at 2,0 m intervals.

c) Stabilising agent report

This report shall comprise details of the actual usage of stabilisation agent.

- Chemical stabilising agent spreading check measurements.
- Bitumen emulsion consumption.
- Straight bitumen consumption.
- Average temperature and pressure measured at the bitumen spray bar.
- All other details shown in the sample report included in the appendices of the latest edition of TG2.

d) Site diary report

This report shall comprise relevant information specifically concerning the reconstruction operation. These shall include but shall not be limited to:

- Stoppage time and cause.
- Sections where in-situ pavement conditions changed from the documented uniform pavement section together with a description of the change.
- Details of any non-routine tests undertaken.
- Any changes in the weather during the day.
- All site instructions received.
- The sampling location of the daily samples of pulverised or broken down material.

C5.5 RECONSTRUCTION OF PAVEMENT LAYERS

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the constructional plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum pay item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Items not measured in this Section

The following required activities will not be measured or paid for separately and the Contractor shall include the cost thereof in other items as deemed appropriate:

1. No additional payment shall be made for work in restricted areas.
2. Drainage and protection of the pavement layers from all damage that may occur for any reason until the Employer has taken over the works.
3. Protection of all existing or new kerbs, channels, sidewalks, lined drains, catch pits, kerb inlets, gratings, culverts, bridges, structures, buildings, road signs, guard rails, street lights, fencing, service pipes or cables and any other items adjacent to, over or under the road that could be damaged by the Contractor's vehicles, construction equipment, or by public traffic being accommodated on or alongside the pavement layers, during the construction of the pavement layers, until the Employer has taken over the works.
4. Repair of all damage to the existing pavement layers after access to the reconstruction site has been given to the Contractor and that may occur before, during or after the construction of the reconstructed or rehabilitated pavement layers up until the Employer has taken over the works.
5. Provision of additional material in excess of the compacted volume of the layers calculated using the layer dimensions given in the Contract Documentation for whatever reason including additional material required for the correct placing, mixing, levelling and compaction of the layers.
6. The removal of oversize material up to 5 % of the compacted layer volume.
7. Construction of tie in joints to new or existing road layers or surfacing.
8. The preparation and the inspection for cracks in an underlying layer after removal of a pavement layer.
9. Excavation of benches in pavement layers when widening an existing pavement
10. The provision and maintenance of covers for stockpiled reclaimed materials
11. The provision of method statements and of the programme of reconstruction work along with regular updates of the programme.
12. The brooming during the slushing process whether by hand or by mechanical means.

(iii) Items to be measured and paid for using payment items specified elsewhere in the specifications

For activities in Table C5.5-1 payment items specified in other Chapters or Sections of the specification, where they relate to work under this Section, will be listed in the Pricing Schedule.

Table C5.5-1: Payment items from other Chapters or Sections

Activity	Section 5.5 reference	Section item reference
Traffic accommodation	A5.5.3.1	Section C1.5 of Chapter 1 – All applicable items
Reclaiming / removing layer material or surfacing	A5.5.7.3c) and A5.5.7.4c)	C4.3 of Chapter 4 – All applicable items
Hauling materials such as: <ul style="list-style-type: none"> • Surplus material from the works • Import material from stockpile for specific layers • Import gravel material from Contractor quarry or borrowpit • Pre-milling material 	Several references	Section C1.7 of Chapter 1 – All applicable items
Clearing and grubbing for reclaimed material stockpile sites	A5.5.5.2	Section C1.6 of Chapter 1 – All applicable items
Construction of stockpile site for materials designated for reconstruction including stabilisation	A5.5.5.2	Sections C4.1, C4.4 of Chapter 4 and C5.4 – All applicable items
Crack sealing	A5.5.3.6	Section C8.5 of Chapter 8 – All applicable items
Surfacing of a patch or of an edge break	A5.5.7.1 and A5.5.7.2	Section C8.8 of Chapter 8 – All applicable items
Saw cutting	A5.5.7.1b)	C4.3 of Chapter 4 and Section C8.8 of Chapter 8 – All applicable items
Stabilisation and agents	A5.5.7.4	Section C5.4 – All applicable items
Processing of pavement layers with conventional construction equipment	A5.5.7.4c)	Section C5.3 – All applicable items
Curing a stabilised layer	A5.5.7.6	Section C5.4 – All applicable items
Tack or prime a layer	A5.5.3.6	Section C8.1 of Chapter 8 – All applicable items
Surfacing a reconstructed layer	Several references	Chapter 8 and Chapter 9 – All applicable items

Activity	Section 5.5 reference	Section item reference
Providing a milling machine and milling	A5.5.7.4c) and e)	Section C4.3 of Chapter 4 – All applicable items
Material testing of exposed layer	A5.5.7.3b)	Item C4.3.1

(iv) **Payment items specifically for this Section of the specifications**

Item	Description	Unit
C5.5.1	Compiling and implementing M&U plans for the reconstruction of an existing road pavement	number (No)

The unit of measurement shall be the number of M&U plans for the reconstruction work. Several plans shall be required as specified in Clauses A5.5.3.8 and A5.5.3.9.

The tendered rate shall include full compensation for gathering all information, compiling the plan(s) and for ensuring the implementation thereof during the reconstruction work.

Item	Description	Unit
C5.5.2	Reconstruction preparatory work	

C5.5.2.1 Undivided carriageway:

- | | | |
|-----|---|----------------|
| (a) | Uniform section from km _____ to km _____ | kilometre (km) |
| (b) | Uniform section from km _____ to km _____ | kilometre (km) |
| (c) | Additional uniform sections | kilometre (km) |

C5.5.2.2 Divided carriageway:

- | | | |
|-----|--|----------------|
| (a) | Uniform section from km _____ to _____ | kilometre (km) |
| (b) | Uniform section from km _____ to _____ | kilometre (km) |
| (c) | Additional uniform sections | kilometre (km) |

The unit of measurement shall be the kilometre of uniform section of road to be reconstructed and rehabilitated, measured along the centre-line of the existing road. Each uniform section shall be measured separately. In the case of an undivided road carriageway this shall be measured once along the centreline. In the case of a divided road carriageway this shall be measured once along each carriageway separately.

The tendered rates shall include full compensation for undertaking all the work required in preparation for reconstruction. This work includes all survey and survey-related work such as setting out, checking the design levels and for preparing the information for submission to the Engineer for approval of the final design levels.

The tendered rates shall also include for the removal of standing water, grass and weeds from the road surface including the shoulders.

Item	Description	Unit
C5.5.3	Construction equipment for sampling of in-situ material for mix design procedure	number (No)

The unit of measurement shall be the number of positions for the sampling of in-situ material for the mix design procedure specified in Section A4.4 of Chapter 4

The tendered rate shall include full compensation for all costs to make available and to transport the recycler and other equipment to each sampling position.

The tendered rate shall also include full compensation to provide the required traffic accommodation during the sampling process as specified in the Contract Documentation

Item	Description	Unit
C5.5.4	Sampling of in-situ material for mix design procedure	number (No)

The unit of measurement shall be the number of positions for sampling of in-situ material for the mix design procedure specified in Section A4.4 of Chapter 4.

The tendered rate shall include full compensation for all costs to operate the recycler and other equipment at each sampling position. This shall include full compensation for breaking up the pavement for sampling and subsequent temporary patching of the sampled location by adding make-up material, chemical stabilising agent, watering, compacting and surfacing the sampled area with a cold asphalt material or a hot asphalt mix or a pre-manufactured seal patch.

The tendered rate shall include full compensation for all labour and other incidentals required for the sampling process and the subsequent delivery of the samples to the testing laboratory.

Item	Description	Unit
C5.5.5	Construction of a trial section using a recycler	cubic metre (m³)

The unit of measurement for the trial section using a recycler shall be the cubic metre of trial section constructed to the depth and width as specified in the Contract Documentation. The quantity shall be calculated based on the cubic metre of the authorised dimensions of the trial section. The trial section shall be at least 150 m long but no more than 200 m long.

The tendered rate shall include full compensation for setting out the trial section, preparing and providing the production plan for the trial section specifically, preparing the existing road surface where required and breaking up the existing layer to the specified depth when this layer has not been specified to be pre-milled or pre-pulverised. When specified, pre-milling or pre-pulverisation will be measured and paid for under item C5.5.7.

The tendered rate shall include breaking down the layer and preparing the material utilising a recycler, adding any extra water required and placing the material followed by the primary and secondary compaction of the material all in accordance with Section A5.5. The rate shall include cutting final levels to tolerance as well as the protection and maintenance of the layer and conducting process control and monitoring, for protecting the adjacent pavement and for the repair thereof should it be damaged.

The tendered rate shall include full compensation for all labour, equipment and incidentals required to reconstruct the pavement layer as specified in the Contract Documentation.

The procurement, storage, spreading and mixing in of the chemical and/or bituminous stabilising agent for the stabilisation of the layer shall be measured and paid for in accord with the relevant payment items of Section C4.4 of Chapter 4 and Section C5.4.

The tendered rate shall include full compensation for any cost incurred by the Contractor while awaiting the approval of the trial section.

Item	Description	Unit
C5.5.6	Construction of a trial section using conventional construction equipment	cubic metre (m³)

The unit of measurement for the trial section using conventional construction equipment shall be the cubic metre of trial section constructed to the depth and width as specified in the Contract Documentation. The quantity shall be calculated based on the cubic metre of the authorised dimensions of the trial section. The trial section shall be at least 150 m but no more than 200 m long.

The tendered rate shall include full compensation for setting out the trial section, preparing and providing the production plan for the trial section and preparing the existing road surface where required. Pre-milling or pre-pulverising of the existing pavement layer shall be carried out as part of the layer preparation when specified in the Contract Documentation. Where specified, pre-milling or pre-pulverisation will be measured and paid for under item C5.5.7.

The tendered rate shall include for processing, which shall include breaking down the material when no pre-milling or pre-pulverisation is specified and for cutting final levels to the specified tolerances, all in accordance with Section A5.3. The tendered rate shall include the removal of up to 5 % oversize material by volume of the compacted layer. The tendered rate shall include the protection and maintenance of the layer, conducting process control and monitoring and protecting the adjacent pavement from being damaged and for the repair thereof should it be damaged.

The tendered rate shall include full compensation for all labour, equipment and incidentals required to reconstruct the pavement layer as specified in the Contract Documentation.

The procurement, storage, spreading and mixing in of the chemical and/or bituminous stabilising agent for the stabilisation of the layer shall be measured and paid for in accord with the relevant payment items of Section C4.4 of Chapter 4 and Section C5.4.

The tendered rate shall include full compensation for any cost incurred by the Contractor while awaiting the approval of the trial section.

Item	Description	Unit
C5.5.7	Pre-milling existing wearing course material	
C5.5.7.1	Pre-milling an asphalt wearing course (depth of pre-milling varies between 10 mm and 40 mm maximum).	square metre (m ²)
C5.5.7.2	Pre-milling a seal wearing course (depth of pre-milling varies between 10 mm and 25 mm)	square metre (m ²)

The unit of measurement shall be a square metre of road surface pre-milled in accordance with the specifications. The quantity shall be calculated based on the square metres of the actual pre-milling areas.

The tendered rates shall include full compensation for pre-milling ahead of reconstruction, for removing the isolated high spots with a minimum milling depth of 10 mm and maximum milling depth of 40 mm or 25 mm for the asphalt wearing course or the seal wearing course respectively.

The tendered rates shall also include for directly loading and removing the milled material, for all plant movement over the site between isolated high spots for providing all equipment, labour, supervision and incidentals for completing the work in accordance with the specifications.

The haul of the material shall be measured from the point of loading at the pre-milling section to the point of off-loading as per Section A1.7 of Chapter 1.

Item	Description	Unit
C5.5.8	Pre-pulverising material in the existing pavement	
C5.5.8.1	Asphalt wearing course (specify nominal depth)	cubic metre (m ³)
C5.5.8.2	Crushed stone base (specify nominal depth)	cubic metre (m ³)
C5.5.8.3	Stabilised crushed stone (specify nominal depth)	cubic metre (m ³)
C5.5.8.4	Stabilised gravel layer (specify nominal depth)	cubic metre (m ³)

The unit of measurement shall be the cubic metre of in-situ measured pavement layer that is pre-pulverised in-situ, regardless of the hardness or type of material encountered in each pavement layer. The quantity shall be calculated from the measurement of the actual width and depth of the layer that is pre-pulverised. The quantity shall not be adjusted to include any allowance for overlaps between adjacent cuts, nor for the number of cuts required to cover the actual width of pre-pulverising.

The tendered rates shall include full compensation for setting out the works, for pre-pulverising each different type of material in the existing pavement structure, for controlling the depth of pre-pulverising, for the addition of water whilst pre-pulverising, for mixing, placing, shaping, cutting levels **and compaction of the pulverised material** as specified.

The tendered rates shall include full compensation for all transport, labour, equipment and incidentals required to pre-pulverise the material as specified.

Item	Description	Unit
C5.5.9	Temporarily blading layer material to windrow	cubic metre (m³)

The unit of measurement shall be a cubic metre of material from an existing pavement layer, temporarily bladed to windrow and measured in its original position before removal.

The tendered rate shall include full compensation for temporarily blading the layer material to windrow and later blading the material back and also for all clearing-up work which may be necessary after the material has been bladed back.

Only material bladed to windrow on the instruction of the Engineer in order to expose the underlying layer shall be measured and paid for.

Material removed and temporarily stockpiled, will not be paid for under this item.

Item	Description	Unit
C5.5.10	Roller-pass compaction of an exposed pavement layer	
C5.5.10.1	Smooth drum vibratory rollers	square metre (m ²)
C5.5.10.2	Other vibratory rollers. (specify _____)	square metre (m ²)
C5.5.10.3	Pneumatic-tyred rollers (PTR)	square metre (m ²)
C5.5.10.4	Other rollers. (specify _____)	square metre (m ²)

The unit of measurement shall be the square metre of exposed pavement layer compacted in accordance with the specification for a single roller-pass. The quantity will be measured in accordance with the authorised dimensions of the area to receive single roller-pass compaction.

The area to be roller-pass compacted shall be adjusted to be commensurate with the number of roller-pass compaction instructed. The authorised area will be doubled when two roller-pass compaction is specified or trebled when three roller-pass compaction is specified in the Contract Documentation, or instructed by the Engineer, and so forth.

The tendered rates shall include full compensation for shaping, providing the rollers, keeping the rollers operational and ready for when soil-moisture conditions are favourable, and for compacting the pavement layer with the specified number of roller-passes.

The Contractor shall base the tendered rates on a single, one direction pass for each specified type, size and weight of roller. The area covered by the nominal roller overlap width required to ensure full coverage of the area being compacted shall not be measured for additional payment. If the rollers available on site are different types, sizes and weights than those specified in the Contract Documentation, then revised rates which take into account the percentage increased or decreased compaction effort per roller-pass, shall be agreed with the Contractor based on the same percentage increase or decrease.

The unit of measurement for the addition of water shall be the kilolitre of water applied as required.

The tendered rates for the addition of water to achieve the required compaction shall include full compensation for the supply, delivery and application of the water when required.

Item	Description	Unit
C5.5.11	Watering the exposed pavement layer	kilolitre (kℓ)

The unit of measurement shall be the kilolitre of water applied to the floor of the excavation that is to be compacted as per the instruction of the Engineer, for roller-pass compaction only.

The tendered rate shall include full compensation for procuring and applying the water, including all transport costs of the water.

Item	Description	Unit
C5.5.12	Removal of surplus material from site	cubic metre (m³)
The unit of measurement shall be the cubic metre of surplus material removed from site. The quantity shall be taken as 70 % of the loose volume measured in the haulage trucks. Accurate truck records shall be kept on site and submitted to the Engineer on a daily basis.		
The tendered rate shall include full compensation for gathering the surplus material by windrowing or pushing it into heaps, for loading and transporting to a designated spoil or stockpile site for offloading and spreading or stockpiling the material.		
The tendered rate shall include full compensation for all labour, equipment and incidentals required to remove the material as specified.		
The haul of the recovered material shall be measured from the point of loading or collection to the point of off-loading as per Section A1.7 of Chapter 1.		

Item	Description	Unit
C5.5.13	Cross mixing of material (specify nominal depth)	cubic metre (m³)
The unit of measurement shall be the cubic metre of material to be cross mixed, as instructed by the Engineer, to ensure lateral mixing of the material. Additional note: Cross mixing only applicable when using a recycler. Cross mixing is part of the construction process when using graders and not payable in that case. The quantity shall be calculated from the actual authorised dimensions of the finally cross mixed and compacted layer. The authorised dimensions shall be as per the Contract Documentation or as instructed by the Engineer.		
The tendered rate shall include full compensation for cross mixing, adding water and spreading the material.		
The tendered rate shall include full compensation for all labour, equipment and incidentals required to complete the cross mixing as specified.		

Item	Description	Unit
C5.5.14	In-situ reconstruction of a pavement layer using a recycler to construct a stabilised selected layer	
C5.5.14.1	Chemically stabilised selected layer compacted to 95 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.14.2	Emulsion stabilised selected layer compacted to 95 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.14.3	Foam stabilised selected layer compacted to 95 % of MDD	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
Item	Description	Unit
C5.5.15	In-situ reconstruction of a pavement layer using a recycler to construct a stabilised subbase layer	
C5.5.15.1	Chemically stabilised subbase layer compacted to 97 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)

C5.5.15.2 Emulsion stabilised subbase layer compacted to 97 % of MDD:		
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.15.3 Foam stabilised subbase layer compacted to 97 % of MDD		
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
Item	Description	Unit
C5.5.16	In-situ reconstruction of a pavement layer using a recycler to construct a stabilised base layer	
C5.5.16.1 Chemically stabilised base layer compacted to 100 % of MDD:		
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.16.2 Emulsion stabilised subbase layer compacted to 102 % of MDD:		
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.16.3 Foam stabilised subbase layer compacted to 102 % of MDD		
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)

The unit of measurement for items C5.5.14; C5.5.15 and C5.5.16 above, shall be the cubic metre of in-situ reconstructed pavement layer, using a recycler, the quantity of which shall be calculated in accordance with the authorised dimensions of the compacted layer.

The tendered rates shall include full compensation for setting out the works, preparing and providing the production plan(s) as per Clause A5.5.8.5a), preparing the existing road surface where required and breaking up the existing layer to the specified depth.

The tendered rates shall include full compensation for breaking down the in-situ layer and preparing the material utilising a recycler, adding any extra water required and placing of the material followed by the primary compaction and secondary compaction of the material. The rate shall include full compensation for cutting final levels as well as the protection and maintenance of the layer, conducting process control and daily monitoring, measuring and demarcating the work where layers are only partly reprocessed and for protecting the adjacent pavement and for the repair thereof should it be damaged.

The tendered rates for items C5.5.14.1d), C5.5.14.2d) and C5.5.14.3d); items C5.5.15.1d), C5.5.15.2d) and C5.5.15.3d) and items C5.5.16.1d), C5.5.16.2d) and C5.5.16.3d) shall also include full compensation for shaping and compacting the pre-pulverised material to 93% MDD.

The tendered rates shall include full compensation for the application of the bituminous stabilising agents in accord with the specifications of Section A5.5.

The layer thickness to be stabilised can be varied by the Engineer by up to 20 mm, and the rate for this stabilisation work shall remain applicable.

The tendered rates shall also include for all labour, equipment and incidentals required to reconstruct the pavement layer.

The procurement, storage, spreading and mixing in of the chemical and/or bituminous stabilising agent for the stabilisation of the layer shall be

measured and paid for in accord with the relevant items of Section C4.4 of Chapter 4 and Section A5.4.

Item	Description	Unit
C5.5.17	In-situ reconstruction of a pavement layer using conventional construction equipment to construct a stabilised selected layer	
C5.5.17.1	Chemically stabilised selected layer compacted to 95 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.17.2	Emulsion stabilised selected layer compacted to 95 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.17.3	Foam stabilised selected layer compacted to 95 % of MDD	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)

Item	Description	Unit
C5.5.18	In-situ reconstruction of a pavement layer using conventional construction equipment to construct a stabilised subbase layer	
C5.5.18.1	Chemically stabilised subbase layer compacted to 97 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.18.2	Emulsion stabilised subbase layer compacted to 97 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.18.3	Foam stabilised subbase layer compacted to 97 % of MDD	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)

Item	Description	Unit
C5.5.19	In-situ reconstruction of a pavement layer using conventional construction equipment to construct a stabilised base layer	
C5.5.19.1	Chemically stabilised base layer compacted to 98 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.19.2	Emulsion stabilised base layer compacted to 102 % of MDD:	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)
C5.5.19.3	Foam stabilised base layer compacted to 102 % of MDD	
(a)	Using non-cemented material compacted to _____ mm thick	cubic metre (m ³)
(b)	Using cemented material compacted to _____ mm thick	cubic metre (m ³)
(c)	Using a combination of non-cemented and cemented material compacted to _____ mm thick	cubic metre (m ³)
(d)	Using pre-pulverised material (as per item C5.5.8) compacted to _____ mm thick	cubic metre (m ³)

The unit of measurement for items C5.5.17, C5.5.18 and C5.5.19 shall be the cubic metre of reconstructed pavement layer, using conventional construction equipment the quantity of which shall be calculated in accordance with the authorised dimensions of the compacted layer.

The tendered rates shall include full compensation for setting out the works, preparing and providing the production plan(s) as per Clause A5.5.8.5a), preparing the existing road surface where required and breaking up the existing layer to the specified depth when this layer has not been specified to be pre-milled or pre-pulverised.

The tendered rates shall include full compensation for processing and compacting the in-situ material, which shall include breaking down any oversize material, all in accord with Section A5.3 and cutting final levels to the specified tolerances. The tendered rates shall include full compensation for the removal of up to 5 % oversize material by volume of the compacted layer as specified in the Contract Documentation. The tendered rates shall include full compensation for cutting final levels. The tendered rates shall include full compensation for the protection and maintenance of the layer, conducting process control and monitoring and protecting the adjacent pavement from being damaged and for the repair thereof should it be damaged.

The tendered rates for items C5.5.17.1d), C5.5.17.2d) and C5.5.17.3d); items C5.5.18.1d), C5.5.18.2d) and C5.5.18.3d) and items C5.5.19.1d), C5.5.19.2d) and C5.5.19.3d) shall also include full compensation for shaping and compacting the pre-pulverised material using one roller-pass compaction with a static weight 15 ton smooth drum roller..

The layer thickness to be stabilised can be varied by the Engineer by up to 20 mm, and the rate for this stabilisation work shall remain applicable.

The tendered rates shall also include for all labour, equipment and incidentals required to reconstruct the pavement layer as specified in the Contract Documentation.

The procurement, storage, spreading and mixing in of the chemical and/or bituminous stabilising agent for the stabilisation of the layer shall be measured and paid for in accord with the relevant payment items of Section C4.4 of Chapter 4 and Section C5.4.

Item	Description	Unit
C5.5.20	Material shortfall or make-up material	
C5.5.20.1	For selected layer	cubic metre (m ³)
C5.5.20.2	For subbase layer	cubic metre (m ³)
C5.5.20.3	For base layer	cubic metre (m ³)

The unit of measurement shall be a cubic metre of make-up material required on the instruction of the Engineer. The quantity will be determined by way of cross-sections unless the Contract Documentation specifies that the quantity shall be taken as 70 % of the loose volume measured in the haulage trucks.

The tendered rates shall include full compensation for procuring, adding and spreading the material over the existing pavement layer to be reconstructed. The tendered rates shall include full compensation for levelling and pre-compacting the material when a recycler will be used to carry out the reconstruction.

The haul of the make-up or shortfall material shall be measured from the point of loading or collection to the point of off-loading as per Section A1.7 of Chapter 1. Material obtained from a commercial source shall include the haul.

Item	Description	Unit
C5.5.21	Finishing the stabilised layer	
C5.5.21.1	Slush trial section with:	
(a)	Water	square metre (m ²)
(b)	Diluted emulsion	square metre (m ²)
C5.5.21.2	Slush reconstructed section with:	
(a)	Water	square metre (m ²)
(b)	Dilute emulsion	square metre (m ²)
C5.5.21.3	Application of a diluted emulsion spray	litre (ℓ)

The unit of measurement for items C5.5.21.1 and C5.5.21.2 shall be the square metre of stabilised layer finished off by slushing with water or diluted emulsion. The area shall be calculated from the authorised dimensions of the actual width and length of the stabilised layer so treated.

The tendered rates for items C5.5.21.1 and C5.5.21.2 shall include full compensation for the provision of all equipment, materials, labour and all other incidentals to slush the layer as specified and for marking out the area to be slushed.

The unit of measurement for items C5.5.21.3 shall be the litre of diluted emulsion, measured at spraying temperature (see Chapter 8), applied in accord with the Contract Documentation or as instructed by the Engineer.

The tendered rates for C5.5.21.3 shall include full compensation for the provision of all equipment, materials, labour and all other incidentals to apply the diluted emulsion fog spray to the layer as specified. The tendered rates shall also include full compensation for marking out the area to be sprayed with the diluted emulsion and for preparing the area as specified in Chapter 8.

The procurement, storage, handling and application of the bituminous emulsion for slushing or for spraying shall be measured and paid for under the relevant items in Section C4.4 of Chapter 4 and Section C5.4 as part of the bituminous stabilising agent.

Item	Description	Unit
C5.5.22	Excavate pavement layers for patching in existing pavements	
C5.5.22.1	Excavate the following layers:	
(a)	Asphalt layers with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm.	cubic metre (m ³)
(b)	Cemented layers with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(c)	Any other layers (<i>specify layer</i>) with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm.	cubic metre (m ³)
C5.5.22.2	Excavate the following layers using labour enhanced methods of construction:	
(a)	Asphalt layers with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(b)	Cemented layers with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)

- (iii) Exceeding 50 m² but not exceeding 100 m², including for edge repairs wider than 250 mm cubic metre (m³)
- (c) Any other layers (*specify type*) with a surface area:
 - (i) Not exceeding 20 m², including for edge repairs wider than 250 mm cubic metre (m³)
 - (ii) Exceeding 20 m² but not exceeding 50 m², including for edge repairs wider than 250 mm cubic metre (m³)
 - (iii) Exceeding 50 m² but not exceeding 100 m², including for edge repairs wider than 250 mm cubic metre (m³)

The unit of measurement shall be a cubic metre of material excavated from the existing pavement including from the edge of the pavement for edge repairs. The quantity shall be calculated in accordance with the authorised dimensions of the excavation.

The specified saw-cutting for the patch shall be measured and paid for under Section C4.3 of Chapter 4.

The tendered rates shall include full compensation for demarcating the excavation, excavating the material, placing the excavated material in temporary stockpiles, for loading the material into haul trucks and for spoiling the material at a designated spoil site.

Payment shall distinguish between the different types of pavement material excavated as described in this item.

The haul of the excavated material shall be measured from the point of loading or collection to the point of off-loading as per Section A1.7 of Chapter 1.

Distinction shall be made in respect of the method of construction specified. Where the excavation of material is specified by means of labour enhancement methods, the tendered rates shall include wheelbarrow transport over a free haul distance of 50 m.

Item	Description	Unit
C5.5.23	Edge break cutting back when narrower than 250 mm	
C5.5.23.1	Edge break cutting back when narrower than 250 mm	metre (m)
C5.5.23.2	Edge break cutting back when narrower than 250 mm using labour enhanced methods of construction	metre (m)

The unit of measurement for cutting back the edges shall be the metre of pavement edge cut back and excavated as specified and measured parallel to the road centreline. This item shall only apply to edge breaks of which the finally repaired width is less than 250 mm.

The tendered rates for cutting back the edge shall include full compensation for demarcating the edge repair cutting the edge to the line as specified in the Contract Documentation or as instructed by the Engineer, excavating the material to the specified depth and for loading all excavated and loose material and hauling to spoil.

The tendered rates shall also include full compensation for labour, material, and all incidentals necessary for completing all the work in accordance with the specifications.

The haul of the excavated material shall be measured from the point of loading or collection to the point of off-loading as per Section A1.7 of Chapter 1.

Distinction shall be made in respect of the method of construction specified. Where the cutting back of edge break is specified by means of labour enhancement methods, the tendered rates shall include wheelbarrow transport over a free haul distance of 50 m.

Item	Description	Unit
C5.5.24	Edge break patching when narrower than 250 mm	
C5.5.24.1	Edge break patching using emulsion treated base (ETB) material to a maximum depth of 150 mm	metre (m)
C5.5.24.2	Edge break patching using labour enhanced methods of construction and (ETB) to a maximum depth of 150 mm	metre (m)

The unit of measurement for patching the edges shall be a metre of pavement edge patched as specified and measured parallel to the road centreline. This payment item shall only apply to edge breaks of which the finally repaired width is less than 250 mm.

The tendered rates for reconstructing pavement edges shall include full compensation for compacting the exposed pavement layer surface on which the new edge is to be constructed.

The tendered rates shall also include full compensation for procuring, furnishing and mixing all materials as specified for ETB material in Clause A4.1.5.14 of Chapter 4, for use in the edge break patch and then placing, compacting and trimming the material to the required lines and levels as per the Contract Documentation or as instructed by the Engineer.

The tendered rates shall also include full compensation for loading the material into haul trucks, handling, labour, material, and all incidentals necessary for completing all the work in accordance with the specifications.

Measurement and payment for the prime and asphalt surfacing for the edge repair shall be made as specified in Chapter 9.

The haul of the excavated material and of the material for the ETB shall be measured from the point of loading or collection to the point of off-loading as per Section A1.7 of Chapter 1.

Item	Description	Unit
C5.5.25	Compacting the floor of the excavation for patching	square metre (m²)

The unit of measurement shall be a square metre of excavation floor compacted and the quantity shall be computed in accordance with the authorised dimensions of the excavation floor.

The tendered rate shall include full compensation for compaction of the floor of the excavation as specified in the Contract Documentation. Payment shall not distinguish between the various methods of compaction or various density requirements.

Item	Description	Unit
C5.5.26	Backfill patching excavations in existing pavements	
C5.5.26.1	Backfill with the following pavement layer material:	
(a)	Chemically stabilised pavement layer material (specify the pavement layer, the material source being from commercial or from stockpile, the % stabilising agent and the % of MDD) for a patch with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(b)	Emulsion treated base, or ETB pavement material (specify the pavement layer, the material source being from commercial or from stockpile, the components as per Clause A4.1.5.14, and the % of MDD) for a patch with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm.	cubic metre (m ³)
C5.5.26.2	Backfill with the following pavement layer material using labour enhanced methods of construction:	
(a)	Chemically stabilised pavement material (specify the pavement layer, the material source being from commercial or from stockpile, the % stabilising agent and the % of MDD) for a patch with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm.	cubic metre (m ³)
(b)	Emulsion treated base, or ETB pavement material (specify the pavement layer, the material source being from commercial or from stockpile, the components as per Clause A4.1.5.14, and the % of MDD) for a patch with a surface area:	
(i)	Not exceeding 20 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(ii)	Exceeding 20 m ² but not exceeding 50 m ² , including for edge repairs wider than 250 mm	cubic metre (m ³)
(iii)	Exceeding 50 m ² but not exceeding 100 m ² , including for edge repairs wider than 250 mm.	cubic metre (m ³)

The unit of measurement shall be a cubic metre of the specified material placed and compacted in accordance with the specified requirements in the Contract Documentation. The quantity shall be computed in accordance with the authorised dimensions of the layer.

The tendered rates shall include full compensation for providing all the compliant material for the specific layer, irrespective of the origin thereof, for all mixing, including mixing all components as specified for ETB material in Clause A4.1.5.14 of Chapter 4, placing, compacting to the specified density and finishing, and also for all machinery, equipment, labour, supervision and other incidentals for executing the work as specified.

The procurement, spreading and mixing of stabilising agents shall be measured and paid for under Section A4.4 of Chapter 4 and Section A5.4.

Measurement and payment for the prime and asphalt surfacing for the patch shall be made as specified in Chapter 8 and/or Chapter 9.

The haul of the material for the various backfill layers shall be measured from the point of loading or collection to the point of off-loading as per Section A1.7 of Chapter 1. The tendered rates for backfilling with commercial material shall include all the transport costs of the commercial material.

Distinction shall be made in respect of the method of construction specified.

QUESTIONS?

BREAK!

2.8 Chapter 20: Quality Assurance
Section 20.1 – Testing materials and
judgement of workmanship



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1

Contents of Section 20.1

- Definitions
- Cost of testing
- Testing methods
- Statistical judgement
- Measurement and payment



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2

Cost of testing (1)

1. Contractor process and acceptance control testing. Cost to be included in rates
2. Contractor process control, Engineer acceptance control testing. Process control cost by Contractor, acceptance control cost by Employer
3. Process and acceptance control testing by independent site/off-site laboratory. Employer pays lab, Contractor contributes by monthly deduction
4. Method to be specified in Contract Documentation



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Cost of testing (2)

How to handle cost of off-site acceptance control testing:

Clause A20.1.3.6b)(iii)

“Any test requested by the Engineer purely for purposes of acceptance control testing, acceptance of products...”

Further in the same subclause:

“The payment of special tests required by the Engineer shall be borne by the Employer for which provision is made in Section C20.1 (item C20.1.2.2)”



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4

Time for testing new mixes (Table A20.1.3-1)

- Concrete – 8 wks
- Asphalt 10 – 16 wks
- Stabilisation – 8 wks
- BSM – 4 wks
- Seals – 2 wks
- Binders – 4 wks



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5

Testing methods

- A20.1.4 – Published test methods
- A20.1.5 – Unpublished test methods
- A20.1.6 – Special tests (For Ch 4 only DMI & WDD)
- Be aware that test methods can be revised and new tests can be published
- Always ensure that the laboratory declares that the latest test methods are used and has reported the test numbers/dates



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6

Responsibility for material compliance

- Clause A20.1.3.1 General
 “The responsibility to deliver the product in terms of the specification shall always remain the obligation of the Contractor in terms of the contract.”
- Quality Assurance:
 - Process control by Contractor
 - Acceptance control by Employer/Engineer



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7

Sampling and testing frequency

- COTO Chapter 20 refers to TMH5
- Process control:
 - TMH5 Clause 5.1
 “Only the minimum number and the most necessary tests should be done”
 “The type and amount of control the Contractor applies should be left largely up to him”
 - COTO Clause A1.2.8.1 “The Contractor shall agree all the process control sampling, testing with the Engineer”
- Acceptance control:
 - COTO Statistical - only relative compaction Chapter 5



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Questions about sampling and testing

- What about GSSDD tests, frequency and number?
- Is frequency the same for each test?
- Is frequency project size related?
- Who pays for these tests?:
 - A20.1.2 Ordinary and special tests Contractor
 - A20.1.3.6b) Special tests Employer, in item C20.1.
 - Contradiction!
- Clarify in Contract Documentation

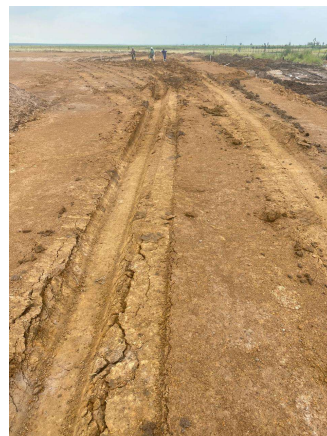


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9

Process control gone wrong



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10

Statistical judgement

- Extensive specification in clause A20.1.7
- Similar to the COLTO but with changes
- Statistical judgement of only selective tests
- For material to be compliant, material shall comply with all the requirements
- If statistical judgement is not used, then alternative judgement must be specified in the Contract Documentation



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11

Measurement and payment

- Item C20.1.5 – Contractor's financial contribution for independent laboratory for his process control portion
- To be priced by Contractor – rate/month
- Time = contract period plus extension of time
- Deducted in monthly in equal amounts



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12

QUESTIONS?



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