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## Introduction

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## Why this course

1. Everything is different and has changed!
2. COLTO is withdrawn and COTO now legal document
3. Earthworks and pavement layers now split in two
4. Course not a verbatim repeat of the COTO
5. Not necessarily a comparison of COLTO/COTO
6. Emphasize on important changes/additions and background to some changes
7. Empower attendants to understand and find the Chapters 4 & 5 specifications



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## Programme for today - mainly 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



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## Programme for tomorrow - mainly Chapter 5

- Review Chapter 4
- 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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## Some logistics about course

1. If a question cannot be answered immediately, I will then respond later, even after the course
2. Most of the time today will be spend on Section 4.1 as it contains the definitions applicable for all other Sections and the material requirements
3. If not enough time today, then sections will roll over
4. Please share experience!



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## History of road specifications

- Pre 1985 – own specifications
  - Mid 1980s – SABS 1200, TRHs, TMHs
  - 1987 – CSRA (KSPO)
  - 1998 – COLTO
  - 2020 – COTO draft standard (**October** version)
  - 2022/2023 – COTO final standard
- SABS (SANS) 1200 not national specification anymore  
COLTO withdrawn  
COTO 2020 full legal standing



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## COTO content

Chapters (15)	Sections (90)
1. General	7
2. Services	4
3. Drainage	3
4. Earthworks and Pavement layers: Materials	5
5. Earthworks and Pavement layers: Construction	5
6. Concrete layers	2
7. Maintenance and repair concrete layers	6
8. Pretreatment and repair existing layers	9
9. Asphalt layers	1
10. Surface treatments	1
11. Ancillary works	9
12. Geotechnical applications	12
13. Structures	14
14. Repair and rehabilitation of structures	11
20. Quality assurance	1



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## COTO Sections

1. Part A: Specifications
2. Part B: Labour enhancement
3. Part C: Measurement and payment
4. Part D: Guarantees and compliance certificates

Part B – Specs to improve the scope for labour, not labour intensive construction. Part A specs apply unless changed in Part B

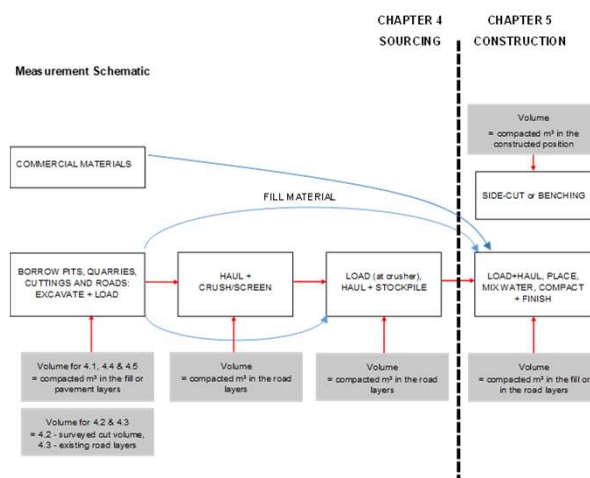


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## Link between Chapter 4 and 5



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#### A4.1.2 DEFINITIONS (p4-2 to p4-5)



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## Definitions (1)

- **Borrow pit area** - an area clearly defined by physical boundaries, that delineate the overall area within which the sourced material is to be excavated, stockpiled and produced
- **Borrow pit** - the excavated area within the borrow pit area
- **Deleterious minerals** - minerals, when present in the natural untreated material, that are detrimental to the road pavement layers. The most common undesirable minerals are sulfide, sulfate, soluble salts and mica
- **Crushed stone type G1 base layer** - is continuously graded, consists of minus 37,5 mm crushed aggregate of high durability, low permeability and low moisture sensitivity, compacted to a high percentage of Apparent Density, and further slush-compacted to refusal or maximum particle interlock



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## Definitions (2)

### Fill material:

- **Sand fill material** comprises of non-plastic sand with not less than 95 % passing through the 5 mm sieve, and which can be compacted to a measurable density.
- **Normal fill material** consists of sand, gravel, gravel with cobbles or alternative materials with a maximum particle size up to 200 mm in the fill and which can be compacted to a measurable density.
- **Coarse fill material** comprises gravel with cobbles, boulders, lumps of hard material or alternative materials with a maximum particle size up to 500 mm, or a maximum particle size so that the material in the fill layer can be compacted to the specified density (measurable or roller-passes).
- **Rock fill material** consists predominantly of blasted or crushed angular rock with fine material filling the voids between the rock. The stability of rock fill results from the mechanical interlock of the rock particles and not from the compaction of the finer material. The compacted density of a rock fill cannot be measured.



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## Coarse fill



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## Coarse fill?



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## Definitions (3)

- **Pioneer layer** - an initial layer constructed with or without a geotextile on a soft and/or wet roadbed to provide a stable working platform for the construction of subsequent layers.
- **Drainage layer** - the drainage layer is constructed over a wet roadbed or in the lower fill layers to provide a stable roadbed, or to intercept water or moisture to prevent it from rising into the road prism and/or the road pavement layers.
- **Macadam layer** - consists of a single graded coarse aggregate with a filler material in the voids between the coarse aggregate.
- **Wearing course** - the gravel layer constituting the uppermost (top) layer of an unsealed road and is not considered part of the structural layers. Its purpose is to provide a maintainable road surface which is skid resistant, dust-free and impermeable to moisture as far as possible.



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## Definitions (4)

- **Unsuitable material** – This is material in or below the roadbed of a quality that would be detrimental to the performance of the completed road. Unsuitable material can be stable or unstable.
- **Stable material** – This is material which have inadequate bearing strength, active (heaving) clay, material with excessive quantity of unwanted material, and the like. Stable material can be removed or excavated efficiently by means of normal road-construction equipment such as bulldozers, road graders, road scrapers, tractor-loader-backhoes (TLBs) or excavators. Stable material may be taken to spoil, or to stockpile for future use depending on the material properties.
- **Unstable material** – This is material which cannot be removed or excavated efficiently by means of bulldozers, road graders, road scrapers, TLBs, or excavators. The material is unstable by virtue of being soaked, such as being located in marsh or swamp conditions, and cannot provide a stable working platform for the construction of subsequent layers. Unstable material is normally left in place and covered with a pioneer layer.



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## Definitions (5)

- **Soil and gravel** - in road construction materials that have a large proportion of fine material in comparison to the coarser material are commonly referred to as "soil(s)". Materials which comprise predominantly of coarser particles with a smaller amount of finer material occurring between the larger particles, and which have good strength due to particle interlock, are described as "gravel(s)". The grading modulus (as defined in TRH 14) of gravel generally exceeds 1,5.
- **Soil constants** - the soil constants of a material comprise:
  - The Atterberg Liquid Limit (LL), Plastic Limit (PL), and Shrinkage Limit (SL).
  - The Plasticity Index (PI).
  - The Linear Shrinkage (LS) and the Linear Shrinkage Modulus (LSM = LS x % passing the 0,425 mm sieve).



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## Definitions (6)

- **Material depth** - the depth below the finished level of the road to which the material characteristics have a significant effect on the pavement behaviour. Below this depth the strength and density of the material are assumed to have a negligible effect on the pavement, except when conditions may arise in the subgrade that require special treatment, such as expansive materials, materials with collapsible or compressible structures, voids or potential sinkholes, mining subsidence, slope instability, non-uniform support or the presence of deleterious minerals.
- **Low volume roads** - low volume roads have a maximum traffic class ES 1, that is a total of 1,0 million 80 kN single axles over 20 years



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## Definitions (7)

- **M&U Plan** - a management and utilisation plan of operations for material sources to ensure that it is worked in a sustainable and sensitive manner, that negative environmental impacts are prevented, material sourcing is optimized and that costs are minimized.
- **Material control personnel** - the personnel for the control of material sourcing and stockpile operations shall be:
  - A **materials manager** who shall be an experienced engineering geologist or engineer, a qualified senior materials technician or an experienced senior general foreman.
  - An **excavation controller** who shall be a materials technician or a general foreman.
  - A **stockpile controller** who shall be an assistant materials technician or a junior foreman.



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## Definitions (8)

- **Weinert N-value** - is a climatic numerical value, which has become known as the N-value. It is calculated by multiplying 12 times the computed evaporation of the warmest month, mostly January in Southern Africa, divided by the mean annual precipitation. **Four N-values are significant:**
  - Where N is **more than 10**, no significant weathering profile develops, and only a thin layer of coarse gravel can generally be obtained from the disintegrating rock.
  - Where N is **between 10 and 5**, disintegration or the physical breakdown of all rocks is the predominant form of weathering, and a deeper weathering profile is usually present.
  - Where N is **between 5 and 2**, decomposition or chemical weathering or more specifically, the alteration of minerals, becomes the predominant form of weathering of crystalline rocks. The clay component is less expansive kaolinite when derived from an acid crystalline rock, and highly expansive montmorillonite when derived from a basic crystalline rock.
  - When N drops **below 2**, decomposed basic crystalline rocks are still expansive. Decomposed acid crystalline rocks may become expansive as montmorillonite may have developed from the little biotite and amphibole present.



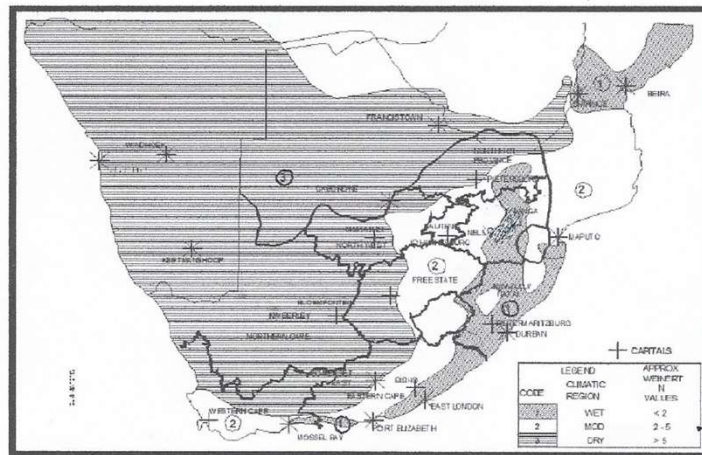
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## Weinert contour lines



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## Contract Documentation (A1.1.2)

- **Contract Documentation** - includes all the documents which define the content and terms of the Contract entered into by the Employer and the Contractor. The Contract Documentation usually consists of the following documents:
  - Conditions of Contract.
  - Contract Agreement.
  - Drawings.
  - Letter or Form of Tender.
  - Letter or Form of Acceptance.
  - Pricing Schedule.
  - Project Specifications.
  - Scope of the Works.
  - Special (or Particular) Conditions of Contract.
  - Standard Specification (this document) and
  - any other documents forming part of the contract



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### A4.1.3 BORROW PITS AND QUARRIES (p4-5 to p4-7)



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## BP & Quarry plans

- Employer identified (A4.1.3.1)
- Contractor identified (A4.1.3.2)
- Negotiations – landowners or legal occupants (A4.1.3.3)



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## M&U plans

1. Structured plan for use of the material source
2. Not only a method statement – items listed in A4.1.3.4
3. Prepared by the Contractor, reviewed and accepted by the Engineer
4. Submitted during construction before development of the source
5. Review after removal of the topsoil and overburden
6. M&U plans are living documents and must be reviewed when circumstances and/or operations changes
7. M&U plans to be workshopped to all personnel involved (Engineer and Contractor)



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## Typical M&U plan content

### A4.1.3.3 Contractor's M&U plan

#### Management and Utilisation Plan

For Borrow pit / Quarry no .....

#### 1. Locality of the BP/Q

- Property description and owner.
- Distance to nearest numbered road or town.
- Other properties between BP/Q and road over which access and haul roads must be constructed.

#### 2. Description of the BP/Q area

- Physical details: mountain, hill, sloping, flat.
- Ground cover: trees, grass, boulders.
- Obstructions: Fences, old buildings, foundations.
- Mitigating factors to be considered: residential, farm housing, roads.

#### 3. Information provided by the Employer

- DME approval.
- Land acquisition or negotiations for BP/Q.
- Land acquisition or negotiations for access and haul roads.
- Topographical survey.
- Geotechnical investigation: test pits, drilling, laboratory test results.
- Depth(s) of excavation.
- Material types and in situ quantities.
- Class(es) of excavation.

#### 4. Proposed supplementary exploration (cl. A4.1.7.2(c))

- Additional test pits and/or drilling (submit plan)
- List laboratory tests.

#### 5. Establishment facilities at BP/Q (submit plan)

- Satellite office and camp site.
- Ablution facilities.
- Refuse refusal facilities.
- Workshops.

#### 6. Haul and access roads (cl. A4.1.7.1)

- Plan of haul and access roads.
- Existing roads and streets: condition (cl. A4.1.7.1(e)).
- New temporary unsurfaced roads: (cl. A4.1.7.1(b) and (c)).
- Negotiations with land owner.

- Crossing of water courses and drainage structures.
- Gates and fences, including open and closed status.
- Pavement structure.
- Maintenance: dust control, blading.

#### 7. Operations prior to the BP/Q

- Existing and new fences.
- Access control.
- Temporary banks and dykes.
- Excavation sequence for fill and layer works.
- Stockpiling of layer work materials.
- Process control tests and frequency.
- Dewatering measures.
- Blasting.
- Crushing and screening.
- Monitoring quality.
- Monitoring quantity.

#### 8. Closure plan

- Side slope and floor details.
- Draining.
- Banks.
- Fencing.

#### 9. Construction equipment

- Excavators.
- Haul vehicles.
- Crushers.

#### 10. OHS

- Issues.
- Inspections.

#### 11. DME

- Conditions.
- Compliance.

#### 12. Reporting

- Content.
- Frequency.



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## Two important activities

- M&U plans and Trial sections
- **Important** to:
  1. Improve control over material quality
  2. Prevent non-compliant brought to road
  3. Extent knowledge of construction
  4. Avoid reconstruction and road failures  
= time, money, disputes, claims



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QUESTIONS?

BREAK!



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## A4.1.5 MATERIALS (p4-7 to p4-20)



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## Southern African rock groups (A4.1.5.2)

Table A4.1.5-1: Grouping of rocks

Group	Members	Characteristics
Basic crystalline rocks	Amphibolite Andesite Anorthosite Basalt Diabase Gabbro Greenschist Norite Peridotite Phonolite Serpentine	Quartz very scarce or absent. The end products of decomposition are clay minerals of the smectite group, particularly montmorillonite. These rocks are more susceptible to decomposition than all others and require the most careful assessment of durability, particularly where relevant N & S.
Acid crystalline rocks	Felsite (quartz porphyry) Gneiss Granite Fragmatite Phyllite Syenite	Orthoclase and quartz are the two major components except in syenite. The end product of decomposition is kaolinite, mostly with quartz, and a smectite stage is absent. May require special attention when used where relevant N & S.
High silica rocks	Chert Microfels Quartzite Vibro Quartz	Composed almost entirely of quartz or amorphous silica. Disintegration is the only mode of weathering. These rocks are the most durable of all road building materials.
Arenaceous rocks	Arkose Conglomerate Gritstone Mica schist Quartzite sandstone Sandstone	Quartz grains in different kinds of matrix. Cementing of matrix determines largely the suitability as road building material. All members are sedimentary rocks. Disintegration is the predominant form of weathering in all environments.
Argillaceous rocks	Mudstone Phyllite Serpentine schist Shale Slate	Essentially rocks composed of clay minerals, often with quartz grains and occasionally with mica. The principal mode of weathering is disintegration.
Carbonate rocks	Dolomite Limestone Marble	Mostly composed of calcite and/or dolomite. The rocks weather only by disintegration or are dissolved when water is present.
Diamictites	Greywacke (although greywacke can also be classified as an arenaceous rock) Tuff Volcanic breccia	Composition extremely random, and is dependent on the incidental mode of formation.
Metallic ores (mining material)	Ironstone (haematite) Magnetite Magnetite	Material from certain mining operations. Durable materials which disintegrate in most cases when weathering.
Pedogenic materials	Calcrete Ferrocrete / laterite Silcrete Oypcrete	Secondarily in place cemented and/or replaced soils with strongest materials on top of the succession. Host soil and cementing material, besides strength, determine the road building properties.



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## General

- Test methods listed in Chapter 20
- There are also other specialised tests
- SANS, BS & AASHTO test procedures and results differ (BS PI 4 units higher than SANS)
- Particle size analysis (grading) – wet preparation
- Compliant material = meet all requirements
- Be aware - Most material properties in all COTO Chapters revised

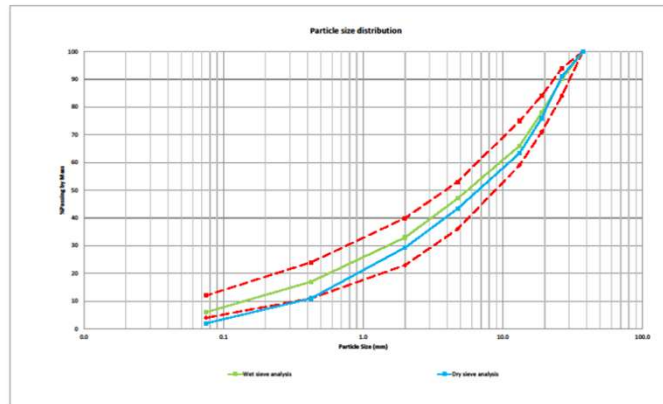


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## Wet vs dry grading



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## Visually prohibited material (A4.1.5..1)

- 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
- Hazardous material (A4.5.5.5)

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## Pioneer layer (A4.1.5.3)

- Predominantly **blasted rock and boulders** (shape not completely rounded or polished), generally in the size range 100 mm to 500 mm, and a lack of material finer than 50 mm.
- Coarse sand** with a plasticity index less than 6.
- Alternative materials** comprising concrete, concrete bricks and hard burnt clay bricks to be also generally in the size range 100 mm to 500 mm, with a lack of material finer than 50 mm



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## Sand, normal and coarse fill (A4.1.5.4)

- Sand:** CBR 7 % , swell  $\leq 1$  % at 100 % MDD
- Normal and coarse fill:**

Table A4.1.5.2: Requirements for normal and coarse fill

Position of the roadbed below the final road surface	CBR and swell
<b>Within the material depth of:</b> <ul style="list-style-type: none"> <li><b>1 200 mm</b> for freeways, major interurban roads, rural and urban arterials. (Class 1/Category A roads).</li> <li><b>1 500 mm</b> for interurban collectors, major rural roads, major commercial roads, urban arterials. (Class 2/Category B roads).</li> <li><b>800 mm</b> for lightly trafficked rural and urban collector and distributor roads, bus routes and commercial roads. (Class 3 and 4/Category C roads).</li> <li><b>600 mm</b> for low volume roads, rural local roads, and urban local residential streets carrying few heavy vehicles. (Class 5/Category D roads).</li> </ul>	CBR $\geq 7$ % at 93 % of MDD. Swell $\leq 2$ % at 100 % of MDD.
<b>Below the applicable material depth up to 10 m</b>	CBR $\geq 3$ % at 93 % of MDD. Swell $\leq 2$ % at 100 % of MDD.
<b>More than 10 m</b>	To be specified in the Contract Documentation, as per the design by an experienced geotechnical engineer of the fill slope, settlement and consolidation, the fill toe protection and drains, the foundation <u>stability</u> and any other design issues.



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### Rock fill (A4.1.5.5)

- Predominantly blasted or crushed angular rock as per the definition
- The following not to be used, except when specified:
  - Mudrock and soft shale
  - Soft basic crystalline rocks Weinert  $N \leq 5$
  - Weathered tillite
- Sand deficiency correction



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### G9 – G6 material (A4.1.5.6 & 7)

- Minor changes
- **G9 – G7:**
  - $PI \leq (3GM + 10)$  (higher value omitted)
  - Calcrete increased to 20
  - CBR of G7 increased to 18 when modified
- **G6:**
  - $PI \leq (2GM + 10)$  (higher value omitted)
  - $LS \leq 7\%$  (not 5 %)
  - CBR max swell reduced to 0,5 % (from 1,0 %)
  - Base MPS 50 mm added



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## G5 and G4 material (A4.1.5.7)

- Major changes
- Now G5A & G5B, G4A & G4B
- G5B & G4B:
  - Material requiring break down by single- or two – stage crushing, or by grid rolling
  - Pedogenic material dozer ripping
  - Only GM (no envelope)
  - MPS according to layer
  - Only difference in min CBR, G5B 45 % @ 95 % and G4B 80 % @ 100 %, and in PI (10 & 6)



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## G5 and G4 material (2)

- G5A & G4A:
  - Medium to hard rock, multi-stage crushing and screening
  - Grading envelope (COLTO G4 uncrushed)
  - MPS 50 mm
  - CBRs as for B-material
- No COLTO G4 crushed envelope anymore



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## G4 – G6 Indicative min material type

- Gravel base layer: G4A to G5B
- Stabilised layer: C2-G4A, C3-G5B, C4-G6
- Bitumen stabilised layer: BSM1-G4B, BSM2-G5B
- Unsealed road base: G5B to G6
- LVR base: G5B
- NB Depend on traffic and climate!



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## G3 – G1 material (A4.1.5.8)

- G3 and G2 COLTO retained
- G1 several changes
- G1 no mine rock or boulders anymore
- Sound (G1-G3), Clean (G2 & G1), Unweathered (G1)
- Sound = adequate strength and durability
- Clean = free from visible traces of materials not from the parent rock
- Unweathered = fresh or faintly weathered rock, no visible signs of alteration in the rock material, discontinuity planes or surfaces may be stained










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## Unweathered rock (1)

<b>Humus/topsoil</b>		
<b>IX</b> Residual soil		All rock material converted to soil: mass structure and material fabric destroyed. Significant change in volume
<b>IX</b> Completely weathered		All rock material decomposed and/or disintegrated to soil. Original mass structure still largely intact
<b>IX</b> Highly weathered		More than 50% of rock material decomposed and/or disintegrated to soil. Fresh/discoloured rock present as discontinuous framework or corestones
<b>III</b> Moderately weathered		Less than 50% of rock material decomposed and/or disintegrated to soil. Fresh/discoloured rock present as continuous framework or corestones
<b>II</b> Slightly weathered		Discoloration indicates weathering of rock material and discontinuity surfaces. All rock material may be discoloured by weathering and may be weaker than in its fresh condition
<b>II</b> Faintly weathered		Discoloration on major discontinuity surfaces
<b>I</b> Fresh		No visible sign of rock material weathering



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## Unweathered rock (2)



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## G1 PI

- $PI_{0,425}$  now according to E80s:
  - E80s > 15 million:  $PI_{0,425} = NP$  (COLTO 5 & 4)
  - E80s  $\leq$  15 million:  $PI_{0,425} \leq 4$
- $PI_{0,075} \leq 8$  (down from 12 and no chemical modification anymore)

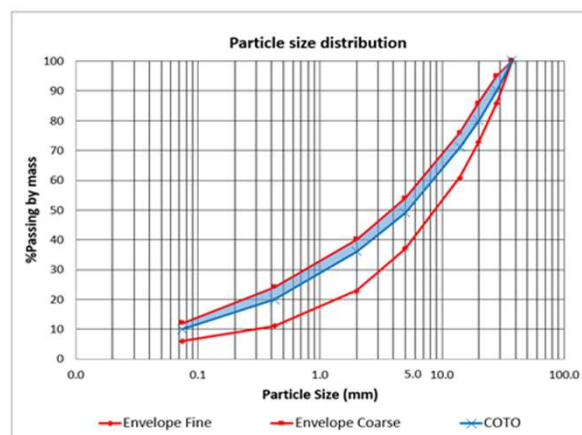


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## G1 grading envelope



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## G1 grading requirement

- No target grading anymore, but still trial section construction to prove grading
- Coarse side is preferable
- The grading lines, when plotted to log scale:
  - shall confirm a **continuous** particle size distribution **within the envelope**,
  - without any **abrupt directional changes** or **meandering**



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## New Specifications for materials not classified in terms of G-type



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### Sand for sealed LVR (A4.1.5.9)

Property		Base and shoulder	Subbase	Selected	Fill
% Passing 2 mm		95 – 100		None specified	
% Passing 0,075 mm (P <sub>0,075</sub> )		5 – 20			
Grading modulus		0,75 – 1,50			
PI on 0,075 mm fraction (PI <sub>0,075</sub> )		SP – 25			
P <sub>0,075</sub> x PI <sub>0,075</sub>		25 – 300			
Strength (CBR at 100 % of MDD)	Soaked	CBR ≥ 50 %	CBR ≥ 30 %	CBR ≥ 15 %	CBR ≥ 7 %
	Unsoaked	CBR ≥ 60 %	None specified		
Swell at 100 % of MDD		Swell ≤ 0,1 %			



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## Other new material specifications

- Macadam – coarse and fine aggregate (A4.1.5.10)
- Unsealed shoulder material, gravel and calcrete (A4.1.5.11)
- Wearing course, gravel and calcrete (A4.1.5.12)
- Drainage layer – coarse and sand (A4.1.5.13)
- Soil cement (soilcrete) wet and stiff mixtures (A4.1.5.14)
- ETB recipe (A4.1.5.15)



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## Durability (A4.1.5.16)

- Applicable G1 – G5A crushed stone in base and subbase layers
- Specifications for basic crystalline, other rocks, and mudrock



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## Durability basic crystalline rocks (1)



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## Durability basic crystalline rocks (2)

Test	Requirement	
	Base material	Subbase material
1. 10 % FACT value after soaking in ethylene glycol for 1 day, compared to the dry value	≥ 80 %	≥ 70 %
2. Ethylene Glycol Durability Index (EGDI)	5 days soaking 20 day : 5 day soaking ratio	EGDI < 10 EGDI < 15 Ratio < 1,5 if 20 day EGDI > 10
2. Durability mill test (dry material test)		
2.1 Index	≤ 80	≤ 125
2.2 Percentage passing 0.425 mm after the test	None specified	≤ 35
2. Product of maximum increase in PI and maximum increase in P <sub>0.425</sub> mm, between the DML <sub>dry</sub> and the DML <sub>soaked for 5 days</sub>	≤ 7	None specified
3. Smectite content using the Spot Counting and/or the Rietveld quantitative XRD (X-ray diffraction) tests	≤ 5 %	None specified
3. Percentage secondary minerals as in the publication "The natural road construction materials of Southern Africa", by HH Weinert	Durability lines in Table 11 on page 95 of the publication	



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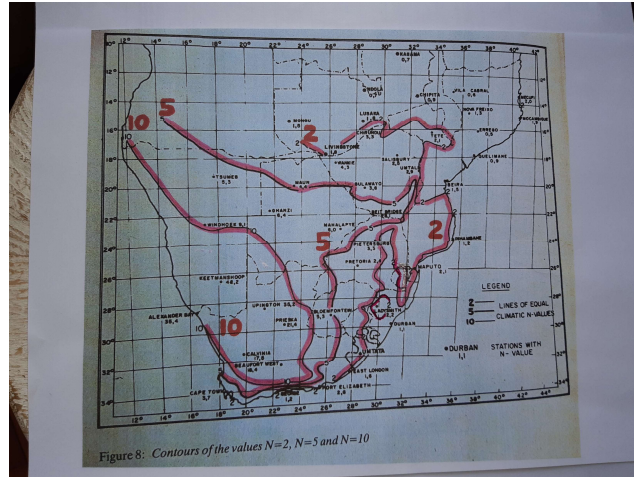


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## Durability basic crystalline rocks (3)

- Areas Weinert  $N \leq 2$ , lime treatment obligatory



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## Deleterious minerals (A4.1.5.17)

- Sulfide
- Soluble salts, acids, sulfates
- Mica



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## Deleterious minerals specifications

Deleterious mineral	Test	Limiting value for use without precautionary measures or treatment of the material	Test method
Total soluble salts	Electric conductivity (Siemens/metre) (S/m)	Base and subbase layers: $\leq 0,15$ ( $\leq 0,10$ ) Selected layers: $\leq 0,40$ (0,20)	TMH1 A21T SANS 6240
Acids	pH	$\geq 6,0$	
Sulfates (calculated as $\text{SO}_3$ )	Acid-soluble sulfate content	Crushed stone material: $\leq 0,05$ % For material to be stabilized: $\leq 0,25$ %	BS 1377:1990 SANS 5850-2
	Water-soluble sulfate content	For material to be stabilized: $\leq 0,25$ % ( $\leq 2,5$ mg/l)	SANS 5850-1



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## Construction water (A4.1.5.18)

- COLTO (1219) – “Only clean water, free from undesirable concentrations of deleterious salts and other materials, shall be used”
- COTO now formalised with specifications that can be applied during construction
- Selected requirements in table in accordance with SANS 241 – drinking water
- Purified water
- Brackish and sea water
- Turbid water



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## Construction water (2)

Purpose	Electric Conductivity (EC) at 25°C (maximum)	Total dissolved solids (TDS) (maximum)	pH range at 25°C	Sulfate as SO <sub>4</sub> (maximum)
1. Crushed stone base layer compaction and slush – compaction	170 mS/m	1200 mg/l	5,0 – 9,7	-
2. Chemical stabilisation compaction and curing	170 mS/m	1200 mg/l	5,0 – 9,7	450 mg/l
3. Bituminous stabilisation	170 mS/m	1200 mg/l	5,0 – 9,7	-
4. Other layers and materials	370 mS/m	2400 mg/l	4,0 – 10,0	-



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## Construction water (A4.1.5.18)

- **Purified water** and other water with visible determinants – Comply with table and extended curing period for stabilised material
- **Brackish and sea water** – use saline water for EC and pH deleterious determination
- **Turbid water** – for crushed stone test effect on PI and P<sub>0,425</sub>



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## Responsibility for material quality (A4.1.5.19)

- Excavation, crushing and in stockpile – Contractor to implement process control testing to monitor quality and quantity
- Construction on the road – Contractor
- Employer identified material – Contractor
- Engineer can declare material non-compliant any time before construction
- Engineer's acceptance control testing only during or after construction
- Engineer and Contractor to agree on testing – A4.1.8
- M&U Plans!



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QUESTIONS?

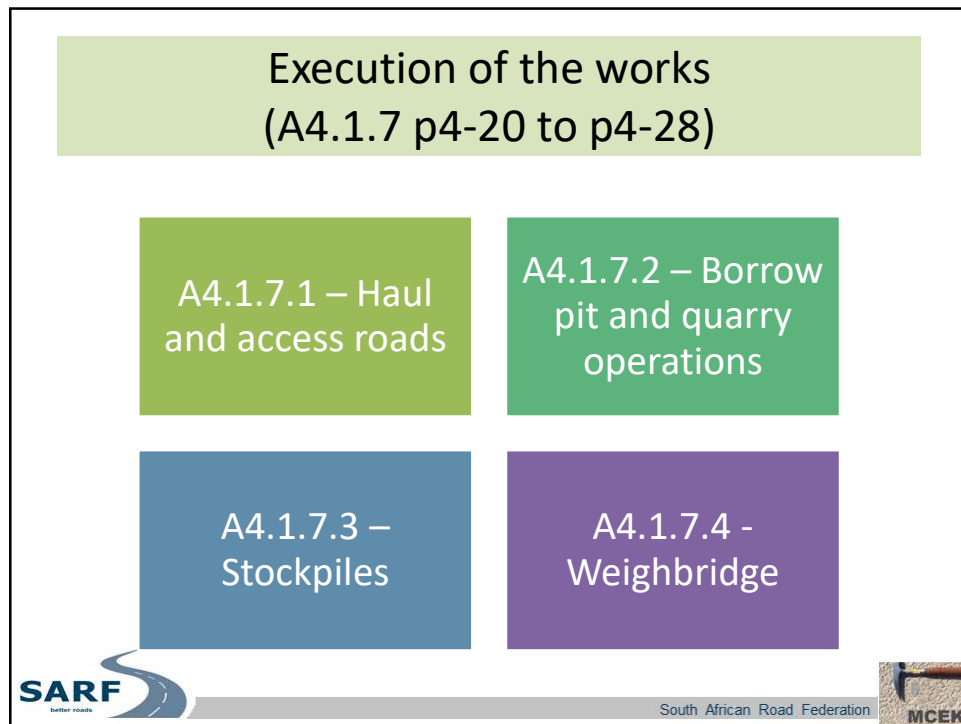
BREAK!



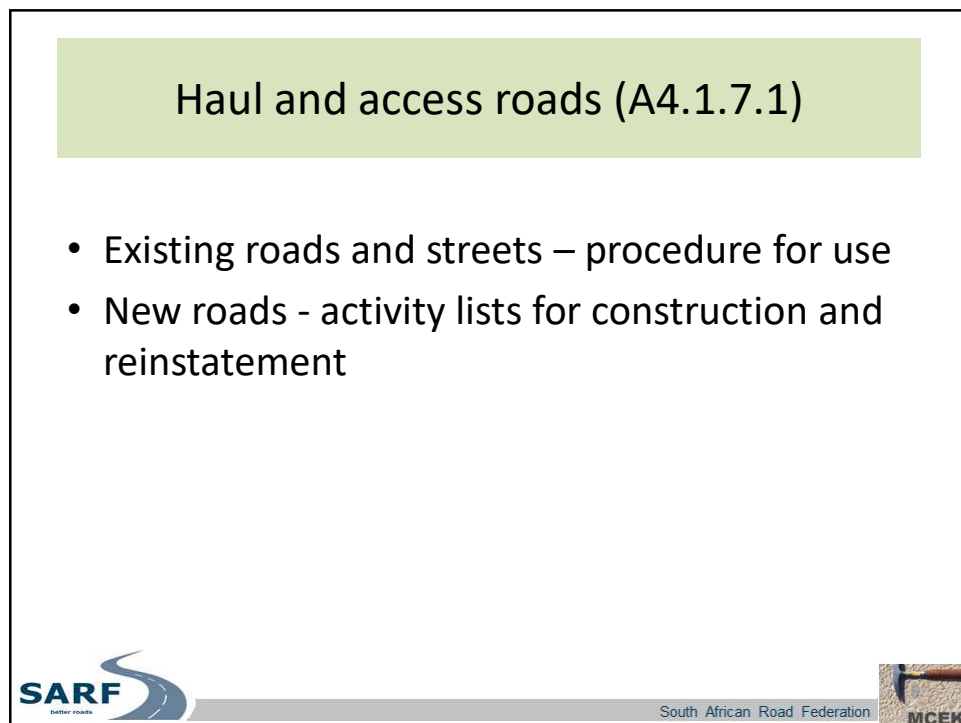
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## Borrow pit and Quarry operations (A4.1.7.2)

### a) General control (1)

- Contractor responsible for operations
- Making safe: fence, access control
- Photographic record, monthly to Engineer
- Selection of compliant materials
- Quantity measurements and reporting
- Actions to be in M&U plan



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## Borrow pit and Quarry operations (A4.1.7.2)

### a) General control (2)

Materials manager for control when specified:

- Full time or part time
- Type of manager (engineering geologist, etc)
- Qualifications and experience



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## Borrow pit and Quarry operations (A4.1.7.2)

### b) Excavation classes (1)

The excavation of borrow material shall be classified as follows:

#### (i) Soft excavation

- Soft excavation class is excavation of material that can be efficiently removed by the reference construction equipment specified in the Contract Documentation, without prior breaking down.
- Very dense granular or sand material and stiff to very stiff cohesive clay material, which can still be removed by the reference construction equipment without prior breaking up as specified for hard material but that do not comply with the definition of efficient removal of the equipment, shall also be classed as soft excavation.
- In the absence of any construction equipment specified to reference the efficient removal of the material, a hydraulic crawler excavator in good mechanical order with nett horsepower (flywheel power) generally between 180 kW and 225 kW, also known as a 30 ton excavator, and equipped with a heavy duty bucket shall be the reference construction equipment. A minimum continuous production rate of 160 m<sup>3</sup>/h of the excavated material will be taken as the benchmark for the excavator's capacity and efficiency.



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## Borrow pit and Quarry operations (A4.1.7.2)

### b) Excavation classes (2)

#### (ii) Boulder excavation class A

- Where material contains in excess of 40 % by volume of boulders, core stones, floaters and lumps of hard material larger than 200 mm but volume less than 20 m<sup>3</sup> in size, in a matrix of soft material, then the full volume excavated shall be classed as boulder excavation class A.
- Excavation in dolomite formations other than solid dolomite shall also be classed as boulder excavation class A if the formations contain in excess of 40 % by volume of lumps of hard dolomite larger than 200 mm but volume less than 20 m<sup>3</sup> in size, in a matrix of softer material or smaller lumps of hard dolomite.
- Excavation of fissured or fractured rock shall not be classed as boulder excavation but as soft or hard excavation according to the nature of the material.

#### (iii) Boulder excavation class B

- Where material contains 40 % or less by volume of boulders, core stones, floaters and lumps of hard material larger than 200 mm but volume less than 20 m<sup>3</sup> in a matrix of soft material, then the volume of the individual boulders, core stones, floaters and lumps of hard material shall be classed as boulder excavation class B.
- The volume of the rest of the material shall be classed as soft excavation.



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## Borrow pit and Quarry operations (A4.1.7.2)

### b) Excavation classes (3)

#### (iv) Hard excavation

Hard excavation is excavation of material, excluding boulder excavation that is classed separately, which **cannot be removed efficiently** by the reference construction equipment specified in the Contract Documentation, and that will **require other means of breaking down before removal** by one of or a combination of the following:

- **Drilling and blasting.**
- **Ripping with a bulldozer.**
- An **excavator fitted** with a hydraulic percussion hammer or fitted with a ripper.
- Hand operated pneumatic or electro-mechanical equipment such as **jackhammers or pavement breakers.**
- Drilling and injecting non-explosive, expansive, silent **rock-breaking cracking products.**

Excavation of individual large boulders, core stones and lumps of hard material **in excess of 20 m<sup>3</sup>** shall also be classed as hard excavation.



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## Borrow pit and Quarry operations (A4.1.7.2)

### b) Excavation classes (4)

- The **Contractor shall be at liberty to use any method and construction equipment** for excavating any class of material, but the chosen method or construction equipment to excavate the material **shall not dictate the classification** of the material.
- **Before any excavation commences the Engineer and the Contractor shall agree on the applicable classes of excavation, based on a visual inspection and the supplementary explorations as in Clause A4.1.7.2c).** Agreement shall also be reached on the method of measurement to be used for boulder excavation or blasted rock prior to the commencement of the excavation.



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## Borrow pit and Quarry operations (A4.1.7.2)

### b) Excavation classes (5)

- In the event of a disagreement between the Engineer and the Contractor, the Contractor shall if instructed, make available such reference construction equipment as specified at no cost to the Employer, in order to determine whether or not the material can be efficiently removed. The decision of the Engineer as to the classification shall thereafter be final and binding, subject to the relevant provisions of the Contract Documentation.
- The Contractor shall immediately inform the Engineer if and when the nature of the material being excavated changes to such an extent that a new classification for further excavation is warranted. Failure to inform the Engineer of any possible change in the class of excavation before the material is excavated, shall entitle the Engineer to classify and measure such excavation as deemed appropriate.



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## Borrow pit and Quarry operations (A4.1.7.2)

### c) Supplementary exploration

- Purpose:
  - Input for M&U Plan
  - Class of excavation
  - Any other information to prevent surprises
- Payment for it, Make use of it!



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## Borrow pit and Quarry operations (A4.1.7.2)

### g) Selection and excavation bps (1)

- Fill excavated and taken directly to the road
- Pavement material excavated and stockpiled separately
- Material broken down during excavation to specified sizes, Contractor to implement changes to comply
- Different material in layers in excavation to be mixed



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## Borrow pit and Quarry operations (A4.1.7.2)

### g) Selection and excavation bps (2)

- Contractor to avoid contamination with poor material
- Duties in M&U plan
- Excavation controller when specified



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## Borrow pit and Quarry operations (A4.1.7.2)

### i) Oversize material

- Less than 5 % - can be taken to road
- More than 5 %, excess mainly a few large particles – remove and do not load large particles, remainder to road
- More than 5 % - Engineer to instruct before loading for either crushing, further breaking down in borrow pit or on road, or avoid during excavation



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## Borrow pit and Quarry operations (A4.1.7.2)

### l) Use of borrow material

- Engineer full control over use of material
- The right to decide which source to be used, even to deviate from programme
- May order selection of material in excavation
- Contractor to plan operations for use of material to best advantage of Employer
- The above at no additional cost to Employer



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## Stockpiles (A4.1.7.3)

### a) Site preparation

- Clear and grub
- Topsoil and overburden remain in place
- Floor min slope of 2 %
- Scarify and compact floor to 90 %
- On steep areas, fill to provide max 5 % slope



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### Stockpiles (A4.1.7.3) b) Stockpiling

- Height of stockpiles – check EMP (This can be an issue)
- Different layered material – 1 m lifts, 3 m max height
- Crushed stone – always stockpile after crushing, dump and level, asses side slopes for segregation
- Do not load bottom 100 mm of stockpile
- Stockpile controller when specified



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### Crushed stone stockpile



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## Weighbridge facility (A4.1.7.4)

- Temporary weighbridge specifications, also to be calibrated
- Office with power supply
- Computer software to record product, truck information
- Weighbridge operator



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## **1.2. Section 4.1 – Borrow Materials**

### **Measurement and Payment**



### A4.1.5.7 Requirements for types G4 to G6 materials for the pavement layers

Gravel, natural occurring or modified or processed, types G4 to G6 materials shall be classified according to the requirements in the Table A4.1.5-4.

**Table A4.1.5-4: Requirements for types G4 to G6 materials**

Property			Type of material				
			G4A	G4B	G5A	G5B	G6
DESCRIPTION OF MATERIAL			Medium to hard rock, or boulders that require multi-stage crushing and screening.	1. Gravel with pebbles and small cobbles, or gravel with larger cobbles, boulders and lumps of hard material, or soft rock that require single- or two-stage crushing, or grid rolling. 2. Pedogenic materials that require dozer ripping.	Medium to hard rock, or boulders that require multi-stage crushing and screening.	1. Gravel with pebbles and small cobbles, or gravel with larger cobbles, boulders and lumps of hard material, or soft rock that require single- or two-stage crushing, or grid rolling. 2. Pedogenic materials that require dozer ripping.	Gravel with cobbles, or alternative materials.
MAXIMUM PARTICLE SIZE			50 mm.	1. In a base layer: 50 mm. 2. In a stabilised subbase layer: 63 mm. 3. In all other pavement layers: Two-thirds of the compacted layer thickness, or 100 mm whichever is the smaller.	50 mm.	1. In a base layer: 50 mm. 2. In a stabilised subbase layer: 63 mm. 3. In all other pavement layers: Two-thirds of the compacted layer thickness, or 100 mm whichever is the smaller.	
FLAKINESS INDEX			Flakiness Index $\leq 35$ on all individual fractions above 14 mm.	None specified.	Flakiness Index $\leq 35$ on all individual fractions above 14 mm.	None specified.	
FRACTURED FACES			None specified.	Gravels and boulders that are crushed: at least 50 % by mass of the material retained on each of the 5 mm and larger sieves shall have at least one fractured face.	None specified.	Gravels and boulders that are crushed: at least 50 % by mass of the material retained on each of the 5 mm and larger sieves shall have at least one fractured face.	None specified.
GRADING ENVELOPE	Sieve size (mm)	Percentage passing sieve, by mass	None specified.	Percentage passing sieve, by mass	None specified.		
	50	100		100			
	37,5	85 – 100		85 – 100			
	20	61 – 91		61 – 91			
	14	48 – 82		48 – 82			
	5	31 – 66		31 – 66			
	2	20 – 50		20 – 50			
	0,425	10 – 30		10 – 30			
	0,075	5 – 15		5 – 15			
GRADING MODULUS (GM)		None specified	1,75 (base) / 1,5 (subbase) – 2,5.	None specified	1,75 (base) / 1,5 (subbase) – 2,5.		
SOIL CONSTANTS ON THE P <sub>0,425</sub> FRACTION <sup>(1)</sup> (= % passing the 0.425 mm sieve)		(a) All materials except calcrete: LL $\leq 25$ . PI $\leq 6$ . LS $\leq 3$ %.  (b) Calcrete: LL $\leq 30$ . PI $\leq 8$ . LSM $\leq 170$ .		(a) All materials except calcrete: LL $\leq 30$ . PI $\leq 10$ . LS $\leq 5$ %.  (b) Calcrete: LL $\leq 45$ . PI $\leq 15$ . LS $\leq 6$ %. LSM $\leq 320$ .		(a) All materials except calcrete: PI $\leq 2$ GM + 10. LS $\leq 7$ %.  (b) Calcrete: LL $\leq 45$ . PI $\leq 15$ . LS $\leq 6$ %, or LSM $\leq 320$ , whichever is the more stringent requirement.	
STRENGTH (CBR at % of MDD)		CBR $\geq 80$ % at 100 %.		CBR $\geq 45$ % at 95 %.  Except In the dry western parts of Southern Africa (Weinert N $\geq 10$ ) and when the E80s < 3 million, then the subbase CBR $\geq 25$ % at 95 % provided that the base thickness $\geq 150$ mm.		CBR $\geq 25$ % at 95 %.	
SWELL AT 100 % OF MDD		Swell $\leq 0,2$ %.		Swell $\leq 0,5$ %.		Swell $\leq 0,5$ %.	
DURABILITY		Specified in Clause A4.1.5.16.					
DELETERIOUS MINERALS		Specified in Clause A4.1.5.17.					

**Note:**

<sup>(1)</sup> The LS and the LSM shall be the primary soil constants for acceptance control of calcrete, and the PI for all other materials.

#### A4.1.5.8 Requirements for types G1 to G3 materials for the pavement layers

Graded crushed stone types G1 to G3 materials shall be classified according to the requirements in Table A4.1.5-5.

**Table A4.1.5-5: Requirements for types G1 to G3 crushed stone**

Property		Type of material				
		G1		G2	G3	
PARENT MATERIAL		Sound <sup>(1)</sup> clean <sup>(2)</sup> unweathered <sup>(3)</sup> high quality rock.		Sound <sup>(1)</sup> clean <sup>(2)</sup> rock and boulders.	Sound <sup>(1)</sup> rock and boulders, or coarse gravel.	
ADDITIONAL FINES		Only fines crushed from the same sound parent rock may be added for grading correction provided that added fines shall have a LL ≤ 25 and a PI ≤ 4. The quantity of fines shall not exceed 10 % by mass.		May contain up to 10 % by mass of approved natural fines not necessarily obtained from the same parent rock. Added fines shall have a LL ≤ 25 and a PI ≤ 6.	May contain up to 15 % by mass of approved natural fines not obtained from the same parent rock. Added fines shall have a LL ≤ 25 and a PI ≤ 6.	
AGGREGATE STRENGTH		10 % Fines Aggregate Crushing Value (10 % FACT) and Aggregate Crushing Value (ACV) specified in table A4.1.5-6				
FLAKINESS INDEX		Flakiness index ≤ 35 on all individual fractions above 14 mm.				
FRACTURED FACES		All faces shall be fractured faces.		For crushed materials at least 50 % by mass of the individual fractions retained on each standard sieve 5 mm and larger shall have at least one fractured face.		
SOIL CONSTANTS	Fraction smaller than	E80s > 15 million	E80s ≤ 15 million	LL ≤ 25. PI ≤ 6. LS ≤ 3 %.	(a) All materials except calcrete: LL ≤ 25. PI ≤ 6. LS ≤ 3 %.  (b) Calcrete: LL ≤ 30. PI ≤ 8. LSM ≤ 170.	
	0,425 mm	PI = NP.	LL ≤ 25. PI ≤ 4. LS ≤ 2 %.			
	0,075 mm	PI ≤ 8				
MAXIMUM PARTICLE SIZE		37,5 mm			37,5 mm	28 mm
GRADING ENVELOPE <sup>(4)</sup>	Sieve size(mm)	Percentage passing sieve, by mass		Percentage passing sieve, by mass	Percentage passing sieve, by mass	
	37,5	100		100	100	----
	28	86 – 90		86 – 95	86 – 95	100
	20	73 – 80		73 – 86	73 – 86	87 – 96
	14	61 – 71		61 – 76	61 – 76	73 – 86
	5	37 – 49		37 – 54	37 – 54	43 – 61
	2	23 – 36		23 – 40	23 – 40	27 – 45
	0,425	11 – 20		11 – 24	11 – 24	13 – 27
	0,075	4 – 10		4 – 12	4 – 12	5 - 12
STRENGTH (CBR at % of MDD)		None specified.			CBR ≥ 80 % at 100 %.	
SWELL AT 100 % OF MDD		None specified.			Swell ≤ 0,2 %.	
DURABILITY		Specified in Clause A4.1.5.16.				
DELETERIOUS MINERALS		Specified in Clause A4.1.5.17.				

**Notes:**

<sup>(1)</sup> Sound – adequate strength and durability.

<sup>(2)</sup> Clean – Free from visible traces of materials not from the parent rock.

<sup>(3)</sup> Unweathered – Fresh or faintly weathered rock with no visible signs under the naked eye of alteration in the rock material, but discontinuity planes or surfaces may be stained or discoloured.

<sup>(4)</sup> The grading lines, when plotted to log scale, shall confirm a continuous particle size distribution within the grading envelope, without any abrupt directional changes or meandering.

Crushed stone for G1 and G2 material shall not be processed from the following rock groups:

- Arenaceous rocks except quartzitic sandstone.
- Argillaceous rocks.
- Pedogenic materials, including calcrete.

## C4.1 BORROW MATERIALS

### 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 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 items describing the activity or other items as deemed appropriate:

1. Loading and hauling to any of the following borrow pit and quarry operations required to source and produce the material that are carried out within the same borrow pit and quarry areas:
  - Removing, and stockpiling if required, of the topsoil and of the overburden.
  - Moving the excavated material between the point of excavation and the stockpile sites or crushing and screening areas, and between the crushing and screening areas and the stockpile sites as applicable.
  - During rehabilitation of the stockpile sites removal of the surplus material, the fill platform, temporary banks and material generated in the finishing.
2. Separating oversize material to be left in the borrow pit.
3. Moving of the construction equipment from one borrow material location to another.

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

For activities in Table C4.1-1 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 C4.1-1: Payment items from other Chapters or Sections**

Activity	Section 4.1 reference	Section item reference
Fencing and gates around the borrow pit and quarry areas	A4.1.7.2a)	Section C11.5 of Chapter 11 - All applicable items
Clearing, grubbing, removal of large trees, and removal of buildings and structures	A4.1.7.2d) and A4.1.7.3a)	C1.6.1 to C1.6.4 of Chapter 1
Conservation (excavating and stockpiling) of topsoil (including overburden less than 200 mm thick)	A4.1.7.2e)	C1.6.9 of Chapter 1
Banks and dykes	A4.1.7.2h) and A4.1.7.3a)	C3.1.6 of Chapter 3
Blasting of hard material	A4.1.7.2j)	C12.10.1 of Chapter 12
Hauling material (when applicable)	A4.1.7.2k) and A4.1.7.3b)	C1.7.2 of Chapter 1
Placing of topsoil, and vegetation	A4.1.7.2m)	Section C11.8 of Chapter 11 - All applicable items

#### (iv) Items specifically for this Section of the specifications

Item	Description	Unit
<b>C4.1.1</b>	<b>Compiling and implementing M&amp;U plans</b>	
C4.1.1.1	For borrow pits (list all borrow pits separately)	number (No)
C4.1.1.2	For quarries (list all quarries separately)	number (No)

The unit of measurement shall be the number of compiled M&U plans for borrow pits and quarries.

The tendered rates shall include full compensation for gathering all information and compiling the plans, for topographical surveys and for ensuring the implementation of the plans during the operation of the borrow pit or quarry.

Item	Description	Unit
<b>C4.1.2</b>	<b>Additional material investigations during the supplementary exploration</b>	
C4.1.2.1	Cost of additional trial pits and/or drilling and laboratory testing	provisional sum
C4.1.2.2	Handling costs and profit in respect of item C4.1.2.1	percentage (%)

Item	Description	Unit
<b>C4.1.3</b>	<b>Construction and maintenance of temporary haul and access roads</b>	
C4.1.3.1	Temporary unsealed roads	kilometre (km)
C4.1.3.2	Cost to repair existing public roads or streets	provisional sum
C4.1.3.3	Handling cost and profit in respect of item C4.1.3.2	percentage (%)

The unit of measurement for item C4.1.3.1 shall be the kilometre of temporary unsealed haul and access roads constructed in the contract.

The tendered rate for item C4.1.3.1 shall include full compensation for all loading and hauling material, constructing the completed road, maintaining it including watering for dust control, removing the road, banks and dykes at the end of its use and for revegetation.

Any haul costs shall be included in the tendered rate of item C4.1.3.1.

Drainage culverts and fencing shall be measured separately.

Item	Description	Unit
<b>C4.1.4</b>	<b>Removing of the overburden</b>	
C4.1.4.1	In borrow pits	cubic metre (m <sup>3</sup> )
C4.1.4.2	In quarries:	
(a)	Soft material	cubic metre (m <sup>3</sup> )
(b)	Hard material (by blasting)	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of overburden removed.

The quantity shall be measured in place at the borrow pit or quarry before stripping. It shall be based on the thickness of overburden as measured in trial pits, or from topographical surveys carried out after the removal of the topsoil and surveys done after the removal of the overburden. Overburden less than 200 mm thick when removed with the topsoil shall be included in the topsoil measurement.

For removing overburden in borrow pits no distinction shall be made between the classes of excavation of the overburden material. For removing overburden in quarries distinction shall only be made between removing soft and hard material.

The tendered rates shall include full compensation for excavating the overburden, for moving the material to the outer limits of the borrow pit or quarry or for loading the material for stockpiling as applicable, for replacing the overburden in the borrow pit or quarry after completion of the excavation including loading and hauling from the stockpile when applicable, and for levelling the material.

The tendered rate for item C4.1.4.2b) shall exclude the cost of blasting, which shall be measured and paid for under item C12.10.1 of Chapter 12.

Approved stockpiling of the overburden shall be measured and paid for under item C4.1.12.

Item	Description	Unit
<b>C4.1.5</b>	<b>Excavating of materials in the borrow pits and quarries, material obtained from</b>	
C4.1.5.1	Soft excavation	cubic metre (m <sup>3</sup> )
C4.1.5.2	Boulder excavation class A	cubic metre (m <sup>3</sup> )
C4.1.5.3	Boulder excavation class B	cubic metre (m <sup>3</sup> )
C4.1.5.4	Hard excavation (other than by blasting)	cubic metre (m <sup>3</sup> )
C4.1.5.5	Hard excavation (by blasting)	cubic metre (m <sup>3</sup> )

The unit of measurement in each class of excavation shall be the cubic metre of material excavated.

The quantities shall be measured in place in the compacted earthworks or pavement layers. The quantities shall not include excess material, overfill material or additional material placed for bulking (settlement during compaction).

The quantities for earthworks shall be measured from the difference between surveyed cross sections at 20 m maximum intervals taken before and after the construction of the earthworks.

The quantities for pavement layers shall be calculated from the authorised dimensions of the layers. Where the pavement layer materials are placed

in stockpile for some time before used on the road, the Engineer and the Contractor shall agree on the interim method of measuring the quantities for this item.

For boulder material the Engineer may approve that the quantities be measured in haul vehicles as an alternative when the boulder material cannot be identified accurately prior to excavating, by taking the volume of the material as equal to 50 % of the loose volume of the material in the haul vehicles.

The tendered rates shall include full compensation for breaking down the materials in the various classes to the specified maximum particle sizes, for excavating, and loading the material.

The tendered rate for item C4.1.5.5 shall exclude the cost of blasting, which shall be measured and paid for under item C12.10.1 of Chapter 12.

Item	Description	Unit
<b>C4.1.6</b>	<b>Providing crushing, screening and related plants</b>	
C4.1.6.1	Single-stage crushing plant	number (No)
C4.1.6.2	Two-stage crushing plant	number (No)
C4.1.6.3	Multiple-stage crushing and screening plant	number (No)
C4.1.6.4	Screening plant	number (No)
C4.1.6.5	Etc, for other plants (as stated by the Engineer and/or the Contractor)	number (No)

The unit of measurement shall be the number of complete plants supplied and erected on the project.

The tendered rates shall include full compensation for providing the plant, transporting the plant to the project, erecting, commissioning and finally dismantling it, and removing it when it is no longer required for the project.

Payment of this item shall be made in two instalments as follows:

- The first instalment, 85 % of the tendered rate, shall be paid after erection and commissioning of the plant.
- The final instalment, 15 % of the tendered rate, shall be paid after removal of the plant from the contract.

Item	Description	Unit
<b>C4.1.7</b>	<b>Producing the material by</b>	
C4.1.7.1	Single-stage crushing	cubic metre (m <sup>3</sup> )
C4.1.7.2	Two-stage crushing	cubic metre (m <sup>3</sup> )
C4.1.7.3	Multiple-stage crushing including screening	cubic metre (m <sup>3</sup> )
C4.1.7.4	Screening only	cubic metre (m <sup>3</sup> )
C4.1.7.5	Etc, for other plants (as stated by the Engineer and/or the Contractor)	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material crushed or crushed and screened and finally used in the construction.

The quantity shall be measured in place in the compacted earthworks or pavement layers. The quantities shall not include excess material, screened out material that is not used in the works, overfill material, or additional material placed for bulking (settlement during compaction).

The quantities for earthworks shall be measured from the difference between levelled cross sections at 20 m maximum intervals taken before and after the construction of the earthworks.

The quantities for pavement layers shall be calculated from the authorised dimensions of the layers.

Where the materials are placed in stockpile for some time before used on the road, the Engineer and the Contractor shall agree on the interim method of measuring the quantities for this item.

The tendered rates shall include full compensation for hauling the material from the excavation to the producing plant, for off-loading and producing the material. The cost of loading the material at or in the excavation shall be included under item C4.1.5.

No haul shall be paid separately for moving material on the same borrow pit or quarry area. Hauling shall only be paid for material moved from another borrow pit or quarry area than where the crushing and screening plant are located. Haul shall then be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.1.8</b>	<b>Moving and re-erecting the crushing, screening and related plants on the site</b>	
C4.1.8.1	Single-stage crushing plant	number (No)
C4.1.8.2	Two-stage crushing plant	number (No)
C4.1.8.3	Multiple-stage crushing and screening plant	number (No)

C4.1.8.4 Screening plant number (No)

C4.1.8.5 Etc, for other plants (as stated by the Engineer and/or the Contractor) number (No)

The unit of measurement shall be the number of times on a site that a plant is dismantled after its initial establishment on site (which is measured and paid for under item C4.1.6), transported and re-erected, irrespective of the type of material produced.

The tendered rates shall include full compensation for dismantling the plant, loading, transporting, off-loading and re-erecting it at new positions, and recommissioning it.

Item	Description	Unit
<b>C4.1.9</b>	<b>Breaking down oversize material</b>	<b>cubic metre (m<sup>3</sup>)</b>

The unit of measurement shall be the cubic metre of oversize material that is broken down.

The quantity shall be measured by the volume of individual boulders or lumps of hard material. Where material is moved for breaking down the Engineer may approve that the quantity be measured by taking the volume to be equivalent to 50 % of the loose volume in the haul vehicles of the material to be broken down, as an alternative to measuring the individual volumes.

Breaking down of the material to the specified maximum particle sizes in Clause A4.1.7.2g) during the excavation operation in the borrow pits or on the road by construction equipment shall not be measured in this item. Only further breaking down by conventional construction equipment of oversize material in or at the borrow pit, as instructed or approved by the Engineer, shall be measured and paid. Additional note: Payment in this item only for further breaking down in the borrow pit Breaking down material on the road in Chapter 5.)

The tendered rate shall include full compensation for breaking down the material.

No distinction shall be made between various methods of breaking down the oversize material.

No haul shall be paid where oversize material must be moved for breaking down.

Item	Description	Unit
<b>C4.1.10</b>	<b>Compacting the floor of the stockpile sites</b>	<b>cubic metre (m<sup>3</sup>)</b>

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

The quantity shall be measured in place at the stockpile site, of the authorised area covered by the stockpile site.

The tendered rate shall include full compensation for scarifying, watering and compaction of the in situ material.

(Clearing and grubbing, and removal of topsoil if applicable, shall be measured and paid for under other items.)

Item	Description	Unit
<b>C4.1.11</b>	<b>Constructing a platform for the stockpile site</b>	<b>cubic metre (m<sup>3</sup>)</b>

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

The quantity shall be measured in place at the platform, from the difference between levels taken after compaction of the stockpile floor and levels taken after the construction of the platform.

The tendered rate shall include full compensation for excavating the material on the stockpile site or elsewhere on the borrow pit or quarry area, moving or loading and hauling the material, for off-loading, and for placing, mixing, watering and compacting the fill material in the platform.

No difference shall be made between different types of fill material.

Any haul costs shall be included in the tendered rate of item C4.1.11.

Item	Description	Unit
<b>C4.1.12</b>	<b>Stockpiling the material</b>	
C4.1.12.1	Material from a producing plant	cubic metre (m <sup>3</sup> )
C4.1.12.2	Material directly from the excavation	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material stockpiled.

The quantity for overburden shall be measured in place before stripping as specified under item C4.1.4.

The quantities for earthworks and pavement layers shall be measured in place in the compacted layers. The quantities shall not include excess material, overfill material, or additional material for bulking.

The quantities for earthworks shall be measured from the difference between levelled cross sections at 20 m maximum intervals taken before and after the construction.

The quantities for pavement layers shall be calculated from the authorised dimensions of the layers.

Where the materials are placed in stockpile for some time before used on the road, the Engineer and the Contractor shall agree on the interim method of measuring the quantities for this item.

The tendered rate for item C4.1.12.1 shall include full compensation for loading the material at the producing plant, hauling the material to the stockpile, off-loading, spreading and maintaining the material in the stockpile.

The tendered rate for item C4.1.12.2 shall include full compensation for hauling the material from the excavation to the stockpile, for off-loading, spreading and maintaining the material in the stockpile. Loading the material at or in the excavation shall be measured under items C4.1.4 and C4.1.5 respectively.

Payment for stockpiling of fill material directly from the excavation shall only be made when the Engineer has given prior approval for stockpiling the fill material.

The temporary stockpiling of material within the borrow pit in heaps with a view to loading, or any other stockpiling method used in connection with the loading method adopted by the Contractor in the borrow pit, shall not be classified as stockpiling for measurement under this item.

No additional measurement apart from this item shall be made for building up a stockpile in different layers for the purpose of mechanical modification of pavement layers on the road.

No haul shall be paid separately for moving material within the same borrow pit or quarry area. Hauling shall only be paid for material moved to a stockpile site not located at the same site as the producing plant (for item C4.1.12.1), or at another borrow pit or quarry area (for item C4.1.12.2). Haul shall then be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.1.13</b>	<b>Removing surplus material from the stockpile</b>	<b>cubic metre (m<sup>3</sup>)</b>

The unit of measurement shall be the cubic metre of stockpiled material not used.

The quantity shall be measured in the haul vehicles by taking the volume to be the equivalent of 70 % of the loose volume of the material in the haul vehicles.

The tendered rate shall include full compensation for loading and hauling the material to the borrow pit or the quarry or a designated site, for off-loading and spreading the material.

Material shall be considered as surplus only when an instruction was given to stockpile the material or where the stockpile material was placed by others. Removal of surplus material resulting from over production by the Contractor shall not be measured and paid.

No haul shall be paid separately for moving material within the same borrow pit or quarry area. Hauling shall only be paid for material moved to a designated site not at the same borrow pit or quarry area. Haul shall then be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.1.14</b>	<b>Removing the fill platform and temporary banks at the stockpile sites upon completion</b>	
C4.1.14.1	Fill platform	cubic metre (m <sup>3</sup> )
C4.1.14.2	Temporary banks	cubic metre (m <sup>3</sup> )

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

The quantity shall be measured in place in the fill platform and the temporary banks, from topographical surveys. The Engineer may approve that the quantity be taken as equal to 70 % of the volume of the loose material in the haul vehicles as an alternative to topographical surveys.

The tendered rates shall include full compensation for loading and hauling the material to the borrow pit or the quarry or a designated site, for off-loading and spreading the material.

No haul shall be paid separately for moving material within the same borrow pit or quarry area. Hauling shall only be paid for material moved to a designated site not at the same borrow pit or quarry area. Haul shall then be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.1.15</b>	<b>Shaping and finishing the borrow pit and quarry areas, and the stockpile sites</b>	
C4.1.15.1	Shaping and finishing the borrow pit and quarry areas, and the stockpile sites:	
(a)	Borrow pits (list all borrow pits separately)	hectare (ha)
(b)	Quarries (list all quarries separately)	hectare (ha)
(c)	Stockpile sites	hectare (ha)
C4.1.15.2	Finishing of the borrow pit and quarry areas, and the stockpile sites using labour enhanced methods of construction:	
(a)	Borrow pits (list all borrow pits separately)	hectare (ha)
(b)	Quarries (list all quarries separately)	hectare (ha)
(c)	Stockpile sites	hectare (ha)

The unit of measurement shall be the hectare of area shaped and finished.

The quantities shall be measured from topographical surveys, measured in plan.

The tendered rates for borrow pits and quarries shall include full compensation for shaping and finishing the sides and floor of the excavation to the

specified slopes and gradients, forming smooth contours using soft material, placing of spoil or excess material in the floor and covering it, removing all excess material, reconstructing temporary berms or constructing new berms, and final preparation of the slopes prior to the topsoiling and revegetation operations.

Replacing overburden not used in the works in the borrow pit or quarry and levelling of the material are included in item C4.1.4.

The tendered rate for stockpile sites shall include full compensation for ripping and shaping the stockpile floor to the original contours. Measurement and payment to remove any surplus material, the fill platform and the temporary banks shall be made under items C4.1.13 and C4.1.14 respectively.

Distinction shall be made between the construction methods used.

Topsoiling and revegetation of the borrow pit and quarry area and stockpile sites will be measured and paid for under other items.

Any haul costs shall be included in the tendered rates of item C4.1.15.

Item	Description	Unit
<b>C4.1.16</b>	<b>Personnel</b>	
C4.1.16.1	Materials manager	month
C4.1.16.2	Excavation controller	month
C4.1.16.3	Stockpile controller	month

The unit of measurement shall be the time in month (or part thereof) that the respective personnel are employed on the contract to carry out the specified duties.

The tendered rates shall include full compensation to cover the full cost of the respective personnel including all overhead charges and profit, bonuses, subsistence, allowances, Contractor's contributions, insurances, accommodation and vehicles for transport.

Item	Description	Unit
<b>C4.1.17</b>	<b>Weighbridge facility</b>	
C4.1.17.1	Providing, erecting and removal of a weighbridge facility	lump sum
C4.1.17.2	Operating the weighbridge	month

The unit of measurement for item C4.1.17.1 shall be the lump sum.

The tendered rate for item C4.1.17.1 shall cover the cost for providing and erecting the weighbridge and the weighbridge office including all fittings, for the power supply, and for providing and calibrating the scale equipment as specified and for the required computer hardware and software.

Payment of the item shall be made in two instalments:

- The first installment, 85 % of the lump sum, shall be paid after the weighbridge is commissioned.
- The final installment, 15 % of the lump sum, shall be paid when the weighbridge and office are removed from the contract.

The unit of measurement for item C4.1.17.2 shall be the time in months or part thereof that the weighbridge facility is operational and used for the works.

The tendered rate for item C4.1.17.2 shall cover the cost for operating and maintaining the weighbridge, including the cost of the weighbridge operator and all incidentals.

Item	Description	Unit
<b>C4.1.18</b>	<b>Compensation to landowners or legal occupants in respect of land acquisition, royalties and/or loss of crops</b>	
C4.1.18.1	Amount allowed, expenditure to be approved or instructed by the Employer	provisional sum
C4.1.18.2	Handling costs and profit in respect of item C4.1.18.1	percentage (%)



**WHERE CRUSHED STONE MATERIAL IS EXCAVATED, PRODUCED AND STOCKPILED FOR USE ON OTHER PROJECTS, THE ITEMS HEREUNDER SHALL APPLY.**

Item	Description	Unit
C4.1.19	<b>Excavating hard material</b>	cubic metre (m <sup>3</sup> ) or ton (t)
Item	Description	Unit
C4.1.20	<b>Producing the material by</b>	
C4.1.20.1	Single stage crushing	cubic metre (m <sup>3</sup> ) or ton (t)
C4.1.20.2	Multi-stage crushing and screening	cubic metre (m <sup>3</sup> ) or ton (t)
C4.1.21	<b>Stockpiling the crushed material</b>	cubic metre (m <sup>3</sup> ) or ton (t)

**The unit of measurement for every item shall be either of the following as specified in the Contract Documentation:**

- **The volume of loose material measured in the stockpile, or**
- **The mass of the material in the stockpile as determined by a weighbridge.**

The tendered rate for item C4.1.19 shall include full compensation for excavating and loading the material.

The tendered rate for item C4.1.20 shall include full compensation for hauling the material from the excavation to the crushing plant, for off-loading and producing the material.

The tendered rate for item C4.1.21 shall include full compensation for loading the material at the producing plant, hauling the material to the stockpile, and for off-loading, spreading and maintaining the material in the stockpile.

No haul shall be paid separately for moving material within the same borrow pit or quarry area. Hauling shall only be paid for material moved to a crushing plant not located at the same borrow pit or quarry area from where the material is excavated, or where the stockpile site is not located at the producing plant. Haul shall then be measured from the point where the material is loaded to where it is off-loaded.

# QUESTIONS?

# BREAK!

### 1.3 Chapter 1: General

#### Section 1.6: Clearing and Grubbing



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#### Section 1.6 Clearing and Grubbing

##### COTO and COLTO comparison

1. Clearing and Grubbing now 2 separate pay items
2. Stumps and roots to be removed to 1 m below cleared roadbed level iso 600 mm
3. No distinction in payment for girths exceeding 3 m
4. Girth measured at 1,5 m above highest point where the tree trunk emerges from the ground iso at its narrowest point in the first 1 m above ground level

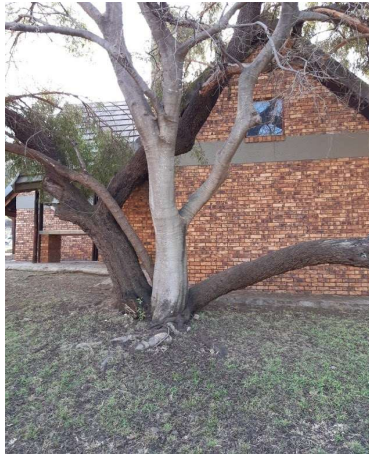


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2

## Girth measurement



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3

## Girth measurement

- COLTO: No specification for multiple trunks
- COTO: Where the tree has several trunks growing from one stump or root, the total for payment shall be the sum of the individual girths of each trunk



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4

QUESTIONS?



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**1.4. Section 12.10 –  
Hard excavation by blasting**

## 12.10 HARD EXCAVATION BY BLASTING

### PART A: SPECIFICATIONS

#### A12.10.1 SCOPE

#### A12.10.2 DEFINITIONS

#### A12.10.3 GENERAL

#### A12.10.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

#### A12.10.5 MATERIALS

#### A12.10.6 CONSTRUCTION EQUIPMENT

#### A12.10.7 EXECUTION OF THE WORKS

#### A12.10.8 WORKMANSHIP

### PART B: LABOUR ENHANCEMENT

### PART C: MEASUREMENT AND PAYMENT

### PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

## A12.10 HARD EXCAVATION BY BLASTING

### PART A: SPECIFICATIONS

#### A12.10.1 SCOPE

This Section covers all aspects of the work and associated operations for controlled drilling and blasting in hard material.

The responsibility for planning and conducting hard excavation by blasting in accordance with the requirements of these specifications, rests solely with the Contractor. **(Additional note: There are several approvals required to be given by the Engineer.)**

Controlled blasting techniques are mandatory for all excavations to limit and/or avoid as required, potential damage to the remaining rock mass, excavated surfaces, infrastructure and property resulting from rock blasting activities. They also minimize fly rock along active routes, within urban areas and within the proximity of any infrastructure or property that could be damaged.

The requirements given hereunder supplement that given in Clause A1.2.7.5 of Chapter 1 and are complimentary to Sections A4.1 and A4.2 of Chapter 4 and any other Chapters that address the excavation of hard materials by blasting. The breaking down and/or crushing or crushing and screening of blasted rock is covered in Chapter 4.

#### A12.10.2 DEFINITIONS

The following definitions, terms, works and expressions are applicable to this section. These are not exhaustive and merely represent a selection used in the field of controlled rock blasting. Accordingly, these do not limit the scope of the blasting that may be required to meet the outcomes and objectives set out in the Contract Documentation.

**Controlled blasting** - includes the use of special techniques, measures, procedures and for using explosives and ancillary materials specially manufactured for this purpose in order to ensure that the required objectives are met without damage to person, property or the works. **(Additional note: Also refer clause 12.10.3. for expansion of definition.)**

**Specified excavation or payment line** - means the excavation profile given on the drawings or determined by the Engineer for the works, within which no unexcavated or loose material shall occur after the excavation is complete except as allowed within the specified tolerances. It is also the line to which payment for excavation will be measured and made. No additional payment will be made for any material excavated or removed beyond this line unless the Contractor can demonstrate that the over excavation was not attributable to negligence or poor workmanship on his part and was due to adverse ground conditions.

**Pre-splitting** - entails blasting utilising closely spaced, parallel drilled holes of appropriate diameter along the intended final excavation surface. These holes may either be vertical or drilled at the inclination specified to establish the specified line in the Contract Documentation and/or shown on the construction drawings. Pre-split holes are charged with a reduced amount of explosive than those for bulk blasting which is decoupled from the wall of the blast hole and may include spacing the explosive charges along the length of the hole if required, i.e. deck charging. These holes are detonated simultaneously, prior to the main bulk blast, to create a single, clean, continuous fracture plane in the rock along the line of drilled holes, thereby creating the final permanent excavation surface with negligible or very limited damage.

**Smooth blasting** - entails drilling a line of closely spaced parallel holes along the intended final excavation surface, with a suitable burden/spacing ratio and loading all the holes lightly with an appropriate amount of explosive, including decked charging if required. These charged holes are detonated, as part of the main blast, but as the last row to be fired, thereby creating the final permanent excavation surface with negligible or very limited damage.

**Line Drilling** - is a method of overbreak control which uses a series of closely spaced holes that are not charged to create a final excavated surface with negligible damage.

**Cover blasting** - entails covering the blast area with material or mats, loading holes lightly with an appropriate amount of explosive and with a suitable burden/spacing ratio to control fly-rock.

**Cushion/Buffer Blasting** - comprises the separate removal of a protective zone of rock which has been purposely left within the specified limits of excavation for flat areas and shallow slopes. Drilling for cushion blasting shall consist of a regular pattern of holes at appropriate spacings and angles and to accurate depths.

The holes shall be lightly charged and detonated in relays to lift the rock progressively to form the final excavated surface without shattering the surrounding rock.

**Air Blast and Over Pressure** - refers to the shock wave travelling through the air resulting from the detonation of explosives. It is measured in decibels.

**Back break** - is the rock broken beyond the limits of the controlled perimeter blast line. Back break may result from blast damage and/or from adversely oriented geological structure within the rock mass.

**Burden** - is the distance between an explosive charge and the nearest free face in metres. In multiple row blasting it is also the distance between two adjacent parallel rows of holes to be fired in succession. Where a free face is available and used for blast design, the burden is the distance between the toe position of the first or front line of the drill holes and the free face.

**Explosive Charge** - is the quantity, ie weight/mass of explosive to be detonated, measured in kilograms.

**ANFO – Ammonium Nitrate Fuel Oil** - is a bulk explosive comprising porous prilled ammonium nitrate with about 6% fuel oil (diesel or kerosene) added to curb moisture absorption.

**Column Charge** - is the length of an explosive charge including any portion of hole drilled below the design grade, loaded in the drill holes to be detonated during the blast.

**Cut-off** - is a portion of an explosive charge that has failed to detonate, either due to the initiation system failing to propagate the whole blast or due to a cut-off in the system as a result of flyrock, ground movement, or system failure.

**Decoupling** - is the use of an explosive charge having a smaller diameter than the diameter of the blast hole it occupies.

**Bulk blasting** - is the excavation of large volumes of material in a blasting action.

**Controlled Perimeter Blasting** - comprises presplitting, smooth blasting, line drilling and cushion blasting techniques to minimize blast vibrations and to optimally limit potential damage and back break to final permanent excavation faces.

**Delay blasting** - is the use of delay detonators or connectors to separate and delay the detonation of explosive charges in a single blast according to a defined time sequence. This limits the amount of explosive detonated instantaneously and thereby limits the level of blast vibrations generated.

**Detonation pressure** - is the pressure created in the reaction zone of the detonating explosive.

**Drill cuttings** - are the fine chippings of rock material which are produced in percussion drilling of the blast holes and blown out as the hole advances.

**Explosives** - are chemicals and chemical mixtures which, when properly initiated, are rapidly converted into gases at high temperature and pressure as the detonation wave propagates through the explosive column. Unconfined, a litre of explosive will expand to around 1 000 litres in milliseconds. Together with the shock wave of detonation, this results in extremely high breaking stresses in rock.

**Free face** - is any unconfined rock surface exposed to air – either natural or created by blasting, located some distance from the blast hole, which reflects the compressional blast induced shock wave, turning it into a reflected tensional wave front which results in breakage and fragmentation of the rock mass.

**Flyrock** - comprises rock fragments propelled through the air by the force of the explosion from a blast.

**Fragmentation** - is a measure to describe the particle (fragment) size distribution of the rock mass broken (fragmented) by the blast. It is normally a measure of the extent to which the rock is broken into small pieces by a primary/bulk blast.

**Ground vibration** - is the ground movement caused by the stress waves emanating from a blast.

**Half barrel** - is the rounded intact rock surface of the blast hole formed by the drilling process which remains sculpted behind on the blast-created rock surface.

**Initiation** - is the act of detonating explosives by appropriate means.

**Maximum Instantaneous Charge** - is the mass of explosive detonated simultaneously, within a single delay interval, as part of a blast.

**Overbreak** - is the amount of rock broken and removed by blasting, and/or subsequent scaling, beyond the specified excavation limit/payment line.

**Peak Particle velocity (PPV)** - is the maximum speed of movement in a given direction of a rock or soil mass recorded as mm/s.

**Secondary blasting** - is blasting undertaken to further breakdown excessively large rocks produced by a blast or re-blasting a portion of the rock mass which did not breakout as required and which remained behind.

**Spacing of blast holes** - is the centre to centre distance between adjacent drill holes in the same row.

**Stemming** - is the portion of the blast hole packed with inert material above the charge so as to confine and retain gasses generated by the explosion during detonation, thus improving the fragmentation process. Inert material used in the stemmed section of the blast hole is also referred to as stemming.

**Toes** - occur at the lower part of the blast near the base of the blast holes and represent a mass of rock that is not broken out by blast. Toes may be caused by misfires, cut-offs or an excessive toe burden. Toes generally require secondary blasting for removal.

## A12.10.3 GENERAL

Implementation of controlled blasting techniques is mandatory for all excavations to limit and/or avoid as required, potential damage to the remaining rock mass, excavated surfaces, infrastructure and property resulting from rock blasting activities. They also minimize fly rock along active routes, within urban areas and within the proximity of any infrastructure or property that could be damaged.

Controlled blasting techniques include:

- Controlled Perimeter Blasting comprising presplitting, smooth blasting and line drilling and cushion blasting techniques to minimize blast vibrations and to optimally limit potential damage and back break to final permanent excavation faces.
- Controlled bulk blasting, which limits the mass of explosives detonated simultaneously per delay in the body of the ground to be excavated, away from the perimeter of the excavation. This is required to reduce ground vibrations to the specified minimum at potentially vulnerable/strategic locations within the zone of influence of the blast. Controlled bulk blasting may affect fragmentation of the rock adversely and could thereby impact on the cost of the loading, hauling and crushing of the rock, all of which the Contractor shall allow and cater for in his programme and rates for undertaking these works.
- Providing a buffer zone of limited width, of reduced spacing, burden, charge mass and other special measures, for blasting the ground between the controlled perimeter blast, and the controlled bulk blast. The buffer zone may either be detonated as part of the controlled bulk blast or as a separate blast, subject to the approval or, instructed by the Engineer.
- Cover blasting shall be used in the vicinity of overhead services (e.g. telephone and power lines) where overhead services may be damaged or affected by blasting activities. The cover blasting shall be such that it sufficiently protects overhead services to prevent any damage to such services.

Controlled blasting shall only be undertaken by suitably experienced and equipped blasting Contractors with proven track record of having successfully undertaken controlled blasting techniques. The works shall be managed and controlled on an on-going daily basis by a works manager/blasting Engineer with a proven track record in the use of controlled blasting techniques.

In the event that the Contractor does not have the necessary experience he shall sub-contract this work to a suitably qualified, experienced and appropriately equipped sub-undertaken controlled blasting techniques. The appointment of a suitable Sub-Contractor shall be subject to the approval of the Engineer.

A copy of all certificates issued to workmen to permit them to undertake blasting, and to the Contractor to cover the purchasing, storage and transport of explosives shall be handed to the Engineer before any blasting work is undertaken.

In the event where excavation is undertaken along an existing route which needs to remain operational, road closures are required during blasting and immediately thereafter whilst clearing of blast debris, which might have landed on trafficked lanes, takes place. To limit the duration of total road closure per blast, and hence time required to clear spoil and repair any road surface damage, only limited sections shall be blasted at a time. This restriction may limit the Contractor's activities and production, and the Contractor shall make due allowance therefore in his rates and programme.

The work shall be programmed so as to minimise blasting adjacent to constructed sections of the Works.

It should be noted that work shall only be performed by personnel listed by the Contractor. If personnel changes need to be made during the project, works shall be suspended until replacement personnel are approved by the Engineer. Time lost due to incomplete submissions, unacceptable submissions, or obtaining approval of replacement personnel will not be considered as cause for extension of time or delay claims. All costs associated with incomplete, replacement, or unacceptable submissions shall be to the Contractor's cost.

### A12.10.3.1 Method Statements

The Contractor shall prepare detailed method statements for each facet of the work describing key aspects such as construction methodology, key plant, materials, personnel as well as any programme constraints of the envisaged construction process. The Contractor shall follow published and proven South African and International Industry Guidelines and Standards for controlled blasting techniques when preparing method statements and designing the blast patterns.

These method statements shall be prepared and submitted to the Engineer for approval prior to commencement of the blasting activities within time scales specified. The onus lies with the Contractor to ensure that the information is obtained and that associated activities are completed expeditiously before blasting operations commence to avoid any delays in the commencement, continuation and completion of the required works. Unless otherwise specified or provided for in the Contract Documentation no permanent works shall be commenced until the Engineer's approval of the relevant method statement. The Contractor shall, however, remain responsible for all work-methods, materials, plant and equipment used, notwithstanding acceptance by the Engineer. The Contractor shall be required to carry out trial blasts to demonstrate that acceptable results will



be obtained. The trials will be used to determine the appropriate combinations of drill hole size, hole spacing, burden, explosive type and charge level, detonating sequence and delays between individual holes or rows of holes to obtain the optimal desired outcome. Rock conditions may vary from place to place and trial blasts are needed to enable adjustments to be made to drilling and blasting techniques and patterns for the relevant conditions.

Trial blasts, shall further be conducted as deemed necessary and /or as ordered by the Engineer for each set of rock mass conditions/differing ground types.

Blasting for confined/restricted excavations requires separate trial blasts to be carried out, before productive work may commence for these excavations. These sections shall be identified and agreed jointly between the Contractor and the Engineer on site as part of the planning and preparations for the commencement of the trial blasts. Other than in the instance of confined/restricted excavations the minimum length and depth of each test section shall be about 20 m and 7,0 m respectively.

The test sections for the trial blasts must as far as possible be undertaken within the volume of the material to be excavated, provided that no charge may be detonated closer than 10 m from any final permanent excavated surface. If this is not possible, a suitable location(s) within identical ground conditions, as close as possible to the site, needs to be identified and agreed to.

Ground vibrations and the damage to the rock surfaces and/or structures and infrastructure noted during the trials will be used to establish the total safe allowable explosive charge to be detonated per delay which the Contractor will not be allowed to exceed for subsequent production blasting.

The quality and adequacy of the results obtained will be jointly assessed by the Engineer and the Contractor and the relevant method statements amended as agreed by both parties Once approved in writing by the Engineer, these shall become the method statements in accordance whereby all blasting shall thereafter proceed for the relevant set of rock mass conditions/ground types.

Notwithstanding, the Engineer may require revision and trial blasts from time to time if circumstances and/or ground conditions during construction arise which warrants change. Trial blasts need to be undertaken and completed and the results accepted by the Engineer at least 2 weeks prior to the commencement of productive work on the particular portion of the contract.

All successful trial blasts approved by the Engineer will be measured and paid for under the relevant drilling and blasting rates. No extension of time or additional time, whatsoever, will be granted to the Contractor for the disruption or for additional associated costs for carrying out trial blasts.

The Contractor shall make due allowance therefore in his programme. Allowance shall also be made for allow for the Engineer's assessment of constructed works, procedures followed, and materials and plant utilised and test data. Production work shall not be permitted until it is shown and accepted by the Engineer that the Contractor possesses the necessary experience, plant and equipment to carry out the works as specified in the Contract Documentation.

Once approved in writing by the Engineer, these shall become the method statements in accordance whereby the relevant portion of the works shall henceforth be executed. Notwithstanding, the Engineer may require revision from time to time if circumstances during construction arise which warrants change.

The supply of any information to the Engineer in respect of the controlled blasting techniques does not relieve the Contractor of his responsibilities under the Contract

### A12.10.3.2 Materials, design and process approvals

The Contractor shall provide comprehensive details of all materials and equipment to the Engineer for his acceptance/approval as provided for in the Contract Documentation within the time frames indicated in Table A12.10.3-1. Where relevant, evidence of compliance with the appropriate specifications shall be provided.

Due allowance shall be made for obtaining such information, resubmissions and re-designs, all to the required/approved standards, methods and practices in attending to these requirements. No consideration for extension of the contract period will be entertained for delays incurred in meeting these requirements.

**Table A12.10.3-1: Approval requirements**

Clause	Approvals required	Period
A12.10.3	Method Statements: Engineers approval of:	
A12.10.7.1a)	Method Statements and Blast Patterns for initial trial blasts.	2 weeks prior to initial trial blasts for the various sections
	Submission of revised Method Statements and Blast Patterns for production blasting following satisfactory trials.	1 week prior to production drilling and blasting.
A12.10.5	Materials approvals: Engineers approval of:	
A12.10.5.1 A12.10.5.2 A12.10.5.3	Explosive type, detonators and initiation system and stemming proposed by Contractor	2 Weeks before trial blasts.
A12.10.7	Process approvals: Engineer's approval of:	

<b>A12.10.7.3 a)</b>	- Preparation and clearing site for each and every blast.	One day before setting out.
<b>A12.10.7.3 b)</b>	- Mark-up and setting of blast holes	One day before drilling.
<b>A12.10.7.3 b)</b>	- Perimeter Blast hole orientation survey	One day prior to charging.
<b>A12.10.7.3 c)</b>	- Depth, spacing and approval of drilled holes ready for charging	One day prior to charging.
<b>A12.10.7.2 c)</b>	Engineer approval that equipment for vibration and over pressure monitoring equipment is in place and in working order	No charging up or blasting pending approval.
<b>A12.10.7.3 f)</b>	Post blast Inspection and approval by the Engineer	Prior to continuing with drilling and blasting
	Assessment of preparatory works rock support	Prior to drilling and blasting for next bench
	<b>Disputes/variations</b>	
<b>A12.10.8.1</b>	Engineer/Contractor disagreement on an outcome of any blast	Works stopped pending receipt of independent specialist' report
<b>A12.10.7.3 f)</b>	Submission of a revised blast pattern when variation in ground conditions is encountered	Engineer's approval required before further drilling and blasting
<b>A12.10.7.3g)</b>	Contractor to submit Required Records timeously	Drilling and Blasting shall only commence receipt of the required records

The Contractor shall comply with the above requirements and shall furthermore give the Engineer at least 24hrs written notification in respect of requests for required inspection(s).

The Contractor shall, notwithstanding his responsibility to design all the blasting required for the contract as per Clause A12.10.4: Design by Contractor and /or in the Contract Documentation, comply with the requirements regarding the timeous provision of and the Engineer's approval of method statements, materials and processes as detailed above, in Table A12.10.3-1: Approval requirements, and as further specified in these specifications. This is to ensure that the appropriate processes and materials are employed and, in view of the permanence of the results, the avoidance of undesirable outcomes.

### **A12.10.3.3 Notification of blasting to all relevant and affected parties**

The Contractor shall give 7 days provisional written notice to all parties engaged on site, relevant authorities and the media of any blasting to be undertaken. The Contractor shall thereafter confirm this provisional notification as a final notification in writing to the relevant and affected parties 24 hours before it is to be carried out. The notification shall show the location of and the intended time of each blast and the contact details and name of the licensed blaster and shift foreman responsible.

Any delay or postponement of any blasts after notifications have been issued shall be conveyed in writing to all relevant and affected parties immediately and if relevant a revised date and time advised.

## **A12.10.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS**

The Contractor shall design all blasting required for the contract. All blasting shall be carried out in accordance with the requirements of these specifications. A suitably qualified and experienced specialist in the field of controlled blasting, the credentials of whom have been accepted by the Engineer, shall sign off on the method statements and shall guide the design of each blast.

The approved specialist shall visit the site of the works on a regular basis and at appropriate times to appraise himself on an on-going basis of the nature and quality of the Contractor's work and the outcome of the blast results. He shall submit a written report on each and every visit undertaken, the table of contents of which will be agreed with the Engineer on site at the commencement of the contract or variations as may be agreed. The report will be submitted via the Contractor to the Engineer within one week of the site visit. The approved specialist shall attend all technical meetings which deal with any aspect relating to drilling and blasting on the contract when required.

If a suitably qualified and experienced specialist is not in the full time employ of the Contractor, the Contractor shall appoint such a specialist at his own cost. All costs associated with procuring the services of the approved blasting specialist and the inputs required will be deemed to be covered in the Contractor's rates for undertaking the works.

The Engineer may also in turn appoint a specialist of his choice to undertake independent reviews of the Contractor's blast designs and method statements. Acceptance by the Engineer or the independent specialist employed by the Engineer of any method statements, blast designs or proposals made by or on behalf of the Contractor, does not relieve the Contractor of his responsibilities and obligations under the contract.

## **A12.10.5 MATERIALS**

### **A12.10.5.1 Explosives**

All explosives proposed to be used by the Contractor are subject to acceptance by the Engineer. The explosives shall be of such quality and power and shall be used in such locations as will achieve the desired result. The firing systems of blasts shall be controlled using reliable approved delay detonators with the requisite degree of accuracy as per submitted design.

The Contractor shall submit comprehensive product data, specification and performance sheets produced and certified by the manufacturer and relevant testing authority as might apply.

#### **a) Controlled perimeter blasting**

Only cartridge explosives, prepared specifically for pre-splitting and smooth blasting, packaged by **explosive manufacturing firms and accepted by the Engineer**, will be permitted for use in controlled perimeter blasting. Appropriately spaced charges will be used in the case of presplitting.

No bulk explosives (such as ANFO) or pumped emulsions shall be used in pre-split, smooth and buffer blast holes.

Maximum diameter of explosives used in pre-split holes shall be less than half the diameter of the pre-split hole unless otherwise approved by the Engineer.

Use of detonating cord may be used in certain applications for pre-splitting and smooth blasting if proven to be successful during trial blasts and provided there are no environmental constraints on its use.

#### **b) Controlled bulk blasting**

Only standard cartridge explosives prepared and packaged by explosive manufacturing firms and accepted by the Engineer shall be permitted for use in controlled bulk blasting.

No bulk explosives such as ANFO or pumped emulsions shall be used in controlled bulk blast holes.

### **A12.10.5.2 Detonators and initiation systems.**

The desired outcome of controlled blasting, in particular where bulk blasting is combined with controlled perimeter blasting is critically dependant on interactions between blast holes. All blasting shall be undertaken using delay detonators and may also require electronic initiation systems to ensure that the required time interval between successive blast holes or rows of blast holes as per the designed sequence is achieved.

**All detonators and initiation systems proposed to be used by the Contractor are subject to the approval of the Engineer.** The Contractor shall submit comprehensive product data, specification and performance sheets produced and certified by the manufacturer and relevant testing authority as might apply.

**Use of capped fuse and igniter cord shall not be allowed unless warranted under special conditions and shall be subject to approval by the Engineer.**

### **A12.10.5.3 Stemming**

**Stemming may only be used with the explicit written approval of the Engineer and the materials used shall be subject to the approval of the Engineer.** As a guideline, when in soft to hard rock, stemming shall consist of drill cuttings sourced from the drilling operation. In hard to extremely hard rock, stemming shall be clean crushed rock with a mean size between 5 % and 10 % of blast hole diameter. **The final selection of the stemming material for each blast shall be subject to acceptance by the Engineer.**

## **A12.10.6 CONSTRUCTION EQUIPMENT**

Drilling shall be undertaken by suitable drills rigs with adequate air flushing to remove drill cuttings efficiently and shall also be equipped with effective dust suppressing and collecting equipment in urban environments.

All drill rigs and equipment shall be in good working order and capable of producing straight holes to required depths, dimensions, tolerances, direction and inclination. Should the type of rig and/or equipment prove inappropriate for the requirements or conditions on site, these shall be replaced by suitable equipment at the Contractor's cost. The drill rig/equipment shall be able to complete all drilling operations, without loss of direction or inclination, in all materials.

Drill bits to be used shall be selected to match the various rock types and rock mass conditions.

## **A12.10.7 EXECUTION OF THE WORKS**

### **A12.10.7.1 General**

#### **a) Benched excavation and rock support**

The excavation will be undertaken in a series of benches, as it becomes deeper, strictly in accordance to the lines and levels indicated on the approved construction drawings. A maximum step out of 1,0 m to allow collaring of the drill rig, for drilling the following bench, will be allowed. In this regard the Contractor shall scrutinize the approved construction drawings for constructability purposes prior to commencing with setting out to ensure that the designed excavated profile can be achieved.

The Contractor's attention is drawn to the possible restriction that rock support may need to be installed within the excavation cycle to stabilise the rock cuttings, thereby interrupting normal production. In this instance the maximum depth of any blast will

not exceed 10m, or such depth as may be specified by the Engineer that can remain temporarily unsupported, whichever is the lesser.

Drilling and blasting of successive benches may not proceed until such time as the required rock support of the preceding bench has been installed as is installed and tested as required by the Engineer. The Contractor shall allow for the costs and disruption in his rates and programme for completing the drilling and blasting work.

**b) Quality and finish of remaining rock**

The Contractor shall ensure that his drilling and blasting techniques do not result in damage to permanent excavated surfaces. The Contractor shall ensure that his blasting techniques will minimize blasting induced fractures or disturbance on the rock mass outside of the excavation line so preserving the rock in the soundest possible condition. The required result of all controlled perimeter blasts is a uniform, clean, even undamaged intact fracture surface without unwarranted overbreak and with the surface of the remaining half barrels of the drill holes intact, with no or minimal fracturing visible within them, all within the tolerances specified.

The Contractor shall accept full responsibility for the quality of the remaining rock surface after a blast and shall make good, at his own expense and as directed by the Engineer, any over-excavation and stabilisation of the rock necessitated by unwarranted blast damage. The Engineer may instruct the Contractor to modify his method of drilling and blasting and to undertake further blasting trials if the required results are not obtained.

In the event of a disagreement between Engineer and Contractor regarding whether a given result rejected by the Engineer can or cannot not be improved upon, all work on drilling and blasting shall stop in that section of the works. The Contractor and the Engineer shall agree upon a recognised, suitably qualified and experienced independent specialist, who shall inspect the section of works in question and provide an opinion whether:

- the results are either acceptable in the opinion of the independent specialist and the Contractor may continue, or,
- they can be meaningfully improved upon in the opinion of the independent specialist, in which case further trial blasts with revised patterns are undertaken before production work may proceed.

The opinion will be binding on both parties. The works shall thereafter proceed in accordance with the revised blast pattern(s), procedures and recommendations approved and made by the independent specialist.

All costs associated with procuring the services of the specialist will be for the Contractors' account. The Contractor shall furthermore not be entitled to any extension of time or extra costs caused by the delay or disruption in halting the work and obtaining the services of the independent specialist.

**c) Fragmentation**

The controlled bulk blast shall be designed and optimised so that a minimum of oversize material is produced (a maximum particle size of 600mm). The Engineer shall have the right to order the Contractor to adjust his blasting pattern and/or carry out secondary blasting or other measures to reduce the size of the rock at his own cost, should he be of the opinion that the Contractor is not taking sufficient care to produce rock meeting the requirements.

**d) Stemming**

No stemming of pre-split holes will be allowed, and these shall be fully vented, except where considerations of noise are overriding. Stemming may only be used for other blasting methods with the explicit written approval of the Engineer.

The length of stemming required for controlled bulk blasting is generally significantly greater than that for bulk blasting and is dependent on rock properties/conditions and degree of confinement and can vary from 20 to 60 times blast hole diameter. Other factors to be considered include:

- Rock conditions
- Blast hole diameter
- Bench height
- Burden
- Explosive strength and density
- Charge length
- Flyrock control
- Air blast limitations

However, if the blast area is well covered or when drilling through thick topsoil, appropriate stemming lengths need to be agreed with the Engineer.

## **A12.10.7.2 Ground vibration, air blast and fly rock monitoring**

The lump sum tendered under this item shall include for providing and operating all equipment necessary to successfully monitor all blasting operations and thereby the Contractor's compliance with the specification. It shall include for all incidentals necessary to operate, process and report results from the equipment.

**a) Monitoring plan and pre-blasting baseline census and survey**

Unless otherwise specified all blasts shall be monitored for ground vibrations, air-blast and by high speed video recording at/from locations/monitoring stations to be agreed with the Engineer. The Contractor shall engage the services of an independent, suitably qualified and experienced reputable specialist consultant(s), accepted by the Engineer to carry out the monitoring and record the requisite data. A minimum of two monitoring stations will be required to be in operation for each and every blast.

The monitoring records of each blast shall show the date, time, weather conditions, location, the type and amount of explosive used, the maximum mass of explosive charge detonated instantaneously and any other relevant data as may be required.

A monitoring plan, indicating the locations of measurement points shall be submitted to the Engineer for approval four weeks prior to the commencement of blasting operations. Monitoring shall include a base-line measurements/census carried out, no more than 10 calendar days prior to blasting indicating the condition of all potentially impacted infrastructure and structures, including cracks and crack widths prior to blasting activities. Thereafter key points/most critical and sensitive structures identified from the census will be inspected immediately after the first two blasts and reported upon and then again once blasting is completed.

Where blasting is conducted over an extended period, regular inspections and censuses, at least at monthly intervals, are required. The consultant will be required to provide a fully documented and illustrated report within 2 weeks of conducting out an inspection.

Where complaints are received of damage caused by blasting, the Contractor shall immediately investigate such and submit a written report to the Engineer on each complaint. If considered valid, the Engineer will instruct the Contractor to obtain a written report from the specialist consultant. The Contractor shall not proceed with any further drilling and blasting on that section of the work until he has been advised accordingly.

In the event of the laid-down vibration parameters set out in Table A12.10.7-1 or those that may be subsequently agreed to following blasting trials for the various sections of the works being exceeded or in the event of a valid recording not being made available as required by these specifications, the Engineer reserves the right to ascertain by whatever means, whether damage was caused by the blast within its potential zone of influence. All costs incurred in establishing such possible resultant damage and the repair thereof will be to the Contractor's account.

#### **b) Establish Site Specific Parameters**

##### *(i) Ground Vibrations*

At the onset of the works and as part of the first blasting trials, the Contractor shall record the peak particle velocities (PPV) using triaxial seismographs and over-pressure using approved industry standard equipment to establish the relationship between these parameters and the distance from the blast and mass of explosives detonated instantaneously. The apparatus shall have the capability of providing both continuous paper trace and digital/analogue records of the data required.

This monitoring and evaluation of the damage to the rock surfaces will be used by the Engineer to establish the total allowable explosive charge to be detonated per delay and detonation patterns and sequences which the Contractor will not be allowed to exceed for subsequent production blasting.

The guidelines for the maximum allowable Peak Particle Velocity (PPV) to prevent damage to structures given in Table A12.10.7-1 shall be adhered to for blasting trials. They will be assessed against results recorded and observed consequences and where necessary the maximum PPV's shall be reduced. The allowable maximum PPVs shall not be increased irrespective of the outcome of observations during blasting trials.

**Table A12.10.7-1: Guidelines for the Allowable Peak Particle Velocity to Prevent Damage (at 50Hz)**

<b>Structure under consideration</b>	<b>Maximum PPV (mm/s)</b>
Onset of fracturing of rock	250
National roads /Asphalt roads	150
Heavily reinforced concrete structures	120
Property owned by the concern performing blasting operations where minor plaster cracks are acceptable	84
Strong masonry walls	50
Steel pipelines	50
Commercial property in reasonable repair	25
Concrete more than 10 days in age	20
Private property	10
Green Concrete i.e. less than 3 days old	5

Note: The onset of damage is a function of the frequency of the vibrations, namely the lower the frequency the lower the limit will be for the onset of damage. The higher frequencies from the blast are first to be attenuated as the vibrations propagate from the source of the blast and are therefore the lowest frequencies that propagate the furthest. The onset of damage is also dependant on the resonant frequency of the structures/infrastructure under consideration. The limits presented in Table A12.10.8-2 are typically for the higher frequency limits, greater than 50 Hz. No more than 5 % of the results shall exceed these limits. The final thresholds for the various elements of the contract will be established from the trial blasts.

At the onset of blasting trials, estimates of Peak Particle Velocity at any distance D in metres for the weight E in kg of explosive detonated instantaneously may be made from Equation 1, namely:

$$PPV = a \left( \frac{D}{\sqrt{E}} \right)^b \dots\dots\dots(1)$$

Where a and b are site specific constants.

Initial values of  $a = 1140$  and  $b = -1.65$  which are common practice in South Africa, shall be used for the initial trials until such time as site specific constants are established.

(ii) *Air blast*

A guideline for the level of perception for various levels of blast pressure and allowable blast pressure is presented in Table A12.10.7-2. These guidelines shall initially be adhered to for blasting trials. They will be assessed against results recorded and observed and where adjudged necessary adjusted as required.

**Table A12.10.7-2: Levels of Perception and Allowable Limits of Blast Pressure**

Level of perception	Blast Pressure (dB)
Readily acceptable – rattling of loose windows/doors/ceiling panels	110
No more than 10 % of measurements should exceed this value.	128
No measurements at any residential or sensitive structures should exceed this limit.	134

Less than 10% of blasts shall be allowed to produce an air blast pressure of more than 128dB at the closest identified sensitive location, and no blast shall generate air blast pressures greater than 134dB.

At the onset of the blasting trials, estimates of air blast at any distance  $D$  in metres for the weight  $E$  in kg of explosive detonated instantaneously may be made from Equation 2, namely:

$$PPV = a - b \log \left( \frac{D}{\sqrt{E}} \right)^b \dots\dots\dots(2)$$

Where  $a$  and  $b$  are site specific constants. Log is log to base 10.

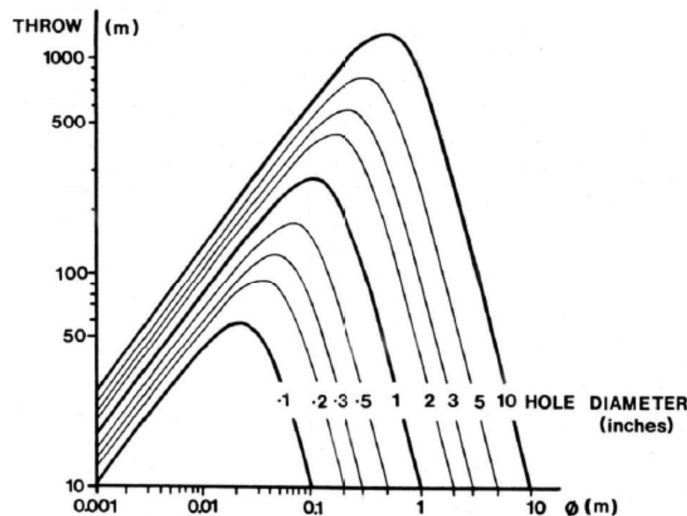
The initial values of  $a = 165 \pm 2.0$  for confined blasts and  $a = 195$  for unconfined blasts. The decay factor  $b \approx 24$ . These values of  $a$  and  $b$  are common practice in South Africa shall be used for initial trials until such time as the site-specific constants are established.

The Contractor shall monitor blast induced ground vibration and air blast levels for each blast. The Contractor shall have sufficient measuring equipment (triaxial seismographs) permanently deployed on site, at the requisite strategic locations, for the duration of drilling and blasting operations to record ground vibrations, air blast and fly rock for all blasts. The equipment shall be correctly set up to capture the full event without exceeding respective sensitivity ranges. The Contractor shall confirm in writing that the equipment is fully operational and appropriately set up 24hrs before commencing to charge any blast and then again immediately prior to detonating the charge.

(iii) *Fly Rock*

The Contractor is required to establish a fly rock risk zone defining the area where fly rock may extend to. This zone shall be cleared before each blast. As fly rock is conservatively considered to be a function of mean predicted blast fragment size and drill hole diameter, fly rock risk zones need to be established for the various blast configurations from the trial blast. Mean predicted blast fragment size is typically determined by way of the KuzrRam model of Cunningham as part of the blast design, see reference 1.

At the onset of blasting trials, minimum estimates of throw distance  $L$  which must be cleared, shall obtained from estimated the graphs for throw distance  $L$  in metres for various mean fragment sizes and blast hole diameters presented in Fig 1 below.



**Figure 1 – Maximum throw of boulders (Lundborg, 1981)**

### A12.10.7.3 Process

#### a) Preparation

Prior to drilling, the Contractor shall commence by removing all overburden, rippable rock and loose material over the area to be excavated to expose the rock requiring controlled blasting. This clearing will extend at least 5,0 m beyond the perimeter of the required blasting limits. Thereafter, depending on the depth of excavation required, blasting will continue in a series of benches/lifts.

Once the slope is scaled of all loose rock and the required support is installed, it shall be cleared of all loose fist size rock and greater, whereafter setting-out and drilling of the following bench may commence.

The Engineer's approval of the clearing shall be obtained one day before the setting out of the holes.

#### b) Drilling

The Engineer's approval of the setting out shall be obtained one day prior to drilling of any blast holes. Drilling accuracy, both to line and level, is of prime importance, especially for controlled perimeter blasting. The Contractor shall take particular care to accurately set out sight lines and guidrails to control alignment, inclination and depth of blast holes

Individual bench heights/lifts shall not exceed 10 m, or that dictated by the rock support requirements indicated in the Contract Documentation, drawings or as determined by the Engineer, whichever is the lesser. The Contractor shall provide safe and appropriate access and opportunity in his programme for subsequent necessary scaling, inspections and mapping by the Engineer and for the installation and testing of rock reinforcement and support as may be needed.

Blast holes shall not be greater than 75 mm in diameter, unless the Contractor can conclusively convince the Engineer by demonstrating by way of successful trial blasts, that a larger diameter is preferable.

Holes shall be accurately set out and collared to within 75 mm of the position indicated on the blast pattern design within the volume of rock that requires to be excavated. No hole may be set out or collared behind the excavation line.

For controlled bulk blasting, cushion and buffer blasting blast holes should not deviate more than 2 %, once collared, from the plane of the planned slope nor and the end of a hole in the plane of the slope should not, deviate more than 2 % of the height of the bench/lift, from the targeted horizontal position. For controlled perimeter blast holes required tolerance of the deviation of the blast holes shall be 1 % as specified above.

The Contractor shall undertake and submit the results of a blast hole orientation survey to the Engineer for approval of all blasts one day prior to planned charging of blast holes. No more than 5 % of the holes shall deviate from the specified tolerances.

Holes, which upon orientation measurement, deviate more than specified percentage (%) from the plane of the slope, or the ends of which deviate more than the specified % of the height of the bench/lift, shall not be charged up, save that 5 % of these holes, provided that the deviation does not exceed 2 % in the case of perimeter holes and 3 % in the case of bulk, cushion and buffer blasting, may be charged as agreed with the Engineer. The remaining out of tolerance holes shall instead be fully filled with stemming and abandoned and a new hole drilled to replace it.

Holes which are over drilled by more than 100 mm of the required depth, shall be stemmed up to the required depth before charging takes place.

Holes for line drilling shall comply with the requirements for bulk blast drilling. Holes shall be strictly drilled at 300 mm centre to centre. Where instructed or approved by the Engineer additional holes shall be drilled to create the desired final excavated surface with negligible damage.

Spacing of pre-split holes shall be such that the result is a uniform, clean, undamaged intact even fracture surface between holes. Any spacing greater than 450 mm shall be subject to the Contractor being able to demonstrate to the Engineer that the required tolerances and a uniform undamaged intact even surface is produced. Notwithstanding the above the maximum allowable hole spacing shall be 750 mm.

Pre-split holes shall extend to at least 200 mm, but not more than 500 mm, below the level of the bulk blast holes.

The line of pre-split holes shall extend beyond either end of the excavation for a distance not less than 10 m beyond the limit of controlled bulk holes to be detonated, or to the end of the cutting as applicable.

The Contractor shall drill one or more rows of buffer holes with reduced charge and burden, adjacent to and inside the pre-split line in such a manner as to avoid damage to the pre-split surface. The buffer holes may not be closer than 1,25 m from the pre-split line of holes.

The Contractor shall adjust his drilling operations to compensate for drift of previous levels and for the offset at the start of new levels to maintain the overall specified sloped plane shown on the drawings and cross sections.

#### c) Charging Up

Twenty four hours prior to charging up or blasting each and every blast, the Contractor shall demonstrate to the Engineer during a joint inspection that all vibration and over pressure monitoring equipment is in place and that the equipment is in 100 % in working order. The Contractor shall provide the Engineer with written confirmation of the foregoing.

The explosive charge of a pre-split or smooth blast shall be decoupled from the wall of the blast hole and the air space between explosive charge and the hole, as may have been established from blasting trials and approved by the Engineer, shall remain open.

The bottom charge of a pre-split or smooth blast hole may be larger than the line charges above it but shall not be large enough to cause damage or excessive back-break of the remaining rock face. The top charge of the pre-split and smooth blast holes shall be placed far enough below the collar to avoid over-breaking and cratering the surface.



All charges shall be accurately made up and inserted into the holes at the correct spacing, and all holes shall be correctly stemmed and linked in the correct sequence with detonators being correctly delayed to ensure the required sequence and timing of detonation and to eliminate the possibility of live charges remaining after detonation.

**d) Sequence of Detonation**

*(i) Pre-splitting*

Dependant on the outcome of the trial blasts, and/or the project requirements, the Contractor may either detonate the pre-split holes:

- Simultaneously, prior to and well in advance of the controlled bulk drilling and blasting which may be done several weeks or months later, or
- Simultaneously, but at least 50 milli-seconds ahead, or such time interval as established from the trial blasts, of the first row of bulk blast holes.
- These holes are detonated simultaneously, prior to the main bulk blast.

*(ii) Smooth blasting*

The row of smooth blast holes is detonated last, after the bulk blast, at least 50 milli-seconds, or such time interval as established from the trial blasts, after the row of buffer holes nearest to the smooth blast line is fired.

*(iii) Controlled bulk blast*

Controlled bulk blasting entails sequentially detonating single rows of blast holes, or portions thereof, starting with the row closest to the free face farthest away from the line of pre-split or smooth blast holes. The sequence of detonation of the rows, or portions of rows must progress in steps, using adequate delay intervals to limit the mass of explosive detonated simultaneously so as to keep ground vibrations to safe limits established for the contract by blast trials.

**e) Variation in Conditions**

The Contractor shall immediately notify the Engineer of changed conditions. All drilling and blasting work shall immediately stop. Prior to commencing with or carrying out any further drilling and blasting, the Contractor obtain the Engineer's approval to proceed with one of the prior approved blasting patterns as determined from the trial blasts.

Should it come to the Engineer's attention that conditions have changed he will instruct the Contractor to **halt all work** immediately and to investigate such. The Contractor shall obtain the **Engineer's approval** of which prior approved drilling and blasting pattern he intends changing to prior to proceeding with any further excavation.

Should conditions be encountered during execution of the works for which no trial blasts were undertaken, the Contractor shall undertake further trials as agreed with the Engineer before continuing with further productive drilling and blasting on that section of the works.

**f) Post blast requirements**

On completion of a blast, the blast created surface/slope shall be scaled and made safe. All blasted material shall be removed along the entire length of the blast and shall be inspected and approved by the Engineer prior to further trial/production drilling and blasting.

The **Engineer's approval** of the preparation, setting out as well as the subsequent installation, testing and proving compliance of any rock support required shall be obtained before any further drilling and blasting pertaining to the next bench of the section of the site under consideration commences.

When completed, the excavated surface (face) of the cutting shall conform to alignment, inclinations and tolerances as shown on the drawings or as might be directed by the Engineer in writing during the execution of the works. The excavated profile shall be checked for line, level and under-break using methods agreed with and approved by the Engineer. Rock protruding more than the allowable tolerance within the payment line shall be removed with mechanical breakers, or other approved non-detonating explosives.

Should the Contractor excavate to dimensions in excess of those specified or instructed by the Engineer, whether to remove damaged material or for reasons of safety or for his own convenience, he shall at his own expense and when required by the Engineer, fill in the excess excavation with concrete or shotcrete of approved quality or with other material approved by the Engineer, or carry out additional trimming to the satisfaction of the Engineer.

All work required and possible delays which result from the Contractor having to remove underbreak as well as having to re-install rock support damaged when removing underbreak, shall be carried out without additional payment or extension of time.

**g) Records**

Without in any way relieving the Contractor and his personnel of their responsibilities in terms of the Explosives Act No.26 of 1956, or any subsequently promulgated relative legislation, the Contractor shall survey and record the actual location of every hole loaded, the charge and timing of every hole, as well as the intended drilling pattern, loading and type of charge in each blast for submission to the Engineer and shall allow the Engineer access to all records maintained for the Inspector of Explosives or Government Mining Engineer as the case may be.

Within 24 hours after every blast the Contractor shall provide the following information to the Engineer:

- Details of the actual total mass of explosives used,
- The approximate volume of material loosened or area pre-split/smooth blasted,
- The maximum simultaneous mass of explosives detonated within the delay intervals, and
- Blast vibration and over pressure and other monitoring results (including video/s of flyrock).



Should the Contractor fail to submit this information as required, the Engineer may instruct that no further drilling or blasting be undertaken until such time as the required information has been received. Any ensuing delay or disruption to the Contractor's programme will be for his own account.

The supply of any information to the Engineer in respect of controlled blasting techniques does not relieve the Contractor of his responsibilities under the Contract. **(Additional note: Very important paragraph concerning the liabilities of the Engineer.)**

#### **h) Use of non-detonating explosives**

Blasting shall not be carried out within 10 m of any works, infrastructure or structure, unless otherwise agreed to in writing by the Engineer. Furthermore, whenever, in the opinion of the Engineer, there is careless or inappropriate use of explosives or where the Engineer considers that further blasting might damage the rock, use of detonating explosives shall be discontinued. In the event of the foregoing the excavation shall be undertaken/completed by either one of the following, namely, propellants, swelling agents, hydraulic wedging or mechanical breakers. In these circumstances, and unless the said conditions and quality of the rock could not have been foreseen, the Contractor shall not be entitled to any additional compensation or extension of time and he shall be reimbursed at the rates tendered for the work as though it had been undertaken by means of detonating explosives.

#### **i) Restrictions**

In addition to the normal statutory restrictions and regulations, blasting shall not be permitted:

- When there is low dense cloud cover of more than 50 %
- When the wind velocity is greater than 10 km/h towards the area of concern
- Before 09h00 and after 16h00
- On Sundays and public holidays
- Unless timeous notifications have been issued to the appropriate parties as per Clause A12.10.3.4.

## **A12.10.8 WORKMANSHIP**

### **A12.10.8.1 Adequacy of the results**

If at any time The Engineer finds that the methods of drilling and controlled blasting employed do not, in his opinion, produce desired results of a uniform slope and clean fractured surface without overbreak and with minimal blast damage, all within the tolerances specified; or result in excessive ground vibrations and damage, he may issue a written instruction to the Contractor to immediately suspend all drilling and blasting. Following this, the Contractor shall investigate and submit a written report on the cause of the alleged inadequate results and/or damage and submit a revised drilling and blasting pattern for approval by the Engineer.

In this instance the Engineer may order that further successful blasting trials be undertaken before full production may continue with the revised pattern.

Should a disagreement between the Engineer and the Contractor arise and the Contractor contends that a given result rejected by the Engineer cannot be improved upon, the Contractor has recourse to Clause A12.10.7.1c) and can call for the opinion by an agreed independent blast specialist and proceed accordingly.



**Blasting holes layout**



**Emulsion delivery truck**



**Detonator and booster**





Timer



Stemming material and set emulsion

QUESTIONS?  
BREAK!

## **1.5. Section 4.2 – Cut Materials**

## 4.2 CUT MATERIALS

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## A4.2 CUT MATERIALS

### PART A: SPECIFICATIONS

#### A4.2.1 SCOPE

This Section covers the work requirements for sourcing natural or crushed materials that can be used for the construction of earthworks and road pavement layers from:

- **New cuttings.**
- **The widening of, or altering the side slopes of, or cutting of benches into existing cuttings.**
- **Box cuts for new roads and from box cuts for the widening of existing roads.**
- **Designated excavations.**

Chapter 5 – Earthworks and Pavement layers: Construction, covers the construction of the road layers.

Specialised cutting slope protection measures are covered in Section 12.9 of Chapter 12.

#### A4.2.2 DEFINITIONS

The relevant definitions in Chapter 1 and Clause A4.1.2 shall also be applicable to this Section. Revised or additional definitions for this Section are listed below.

**Cuttings** - are shallow or deep excavations made in the in situ material required for the construction of the road within the road reserve where the road level results in a cutting slope or batter to be constructed and finished. Further or additional excavations, also referred to as under cuts, below the road pavement layers to remove unsuitable stable material in the same excavation operation within the cutting shall be deemed part of the cutting excavation.

**Box cuts** - are shallow excavations made in the in situ material required for the construction of the road pavement layers below the natural ground level. Additional or further excavations, also referred to as under cuts, below the pavement layers to remove unsuitable stable material in the same excavation operation within the box cut shall be deemed part of the box cut excavation. Box cuts are backfilled with the pavement layer, fill or with other compliant material. Unlike cuttings and designated excavations, box cuts do not have side slopes that must be finished.

**Cut material** - any material excavated from cuttings, box cuts or designated excavations.

**Designated excavations** - are excavations for open drains and channels, canals including channels to direct the course of water flow, that can yield compliant material for use in the works. The excavation criteria for open drains and channels to be classified as designated excavations are provided in Table A3.1.7.2-1 of Chapter 3.



**Typical box cut**

### **A4.2.3 GENERAL**

#### **A4.2.3.1 Employer requirements**

The geotechnical information provided for the cuttings, box cuts and designated excavations reflects the results of site investigations including the excavation of trial pits and/or drilling, and laboratory tests conducted by or on behalf of the Employer. This information is indicative of, but not confirmation of, the sufficiency in quantity and quality of the material.

The Contractor shall use materials strictly in accordance with the requirements in the Contract Documentation and as instructed by the Engineer. The Contractor shall ensure that compliant materials are not unnecessarily contaminated with non-compliant material and that cut materials are not wasted.

All cuttings, and designated excavations where appropriate, must be surveyed and correctly staked before any cut operations commence to ensure that the designated cut lines and slopes are adhered to.

The Contractor shall be instructed as to the applicable usage of the material supply always employing the best economic alternative (lowest construction cost in terms of tendered rates) taking cognizance of the following:

- Quality of material,
- Haulage distance,
- Hardness of the material, and
- Overburden removal and use.

The Contractor shall not use cut material for any purpose other than the execution of this contract. Material shall not be disposed of, whether processed or not, either by sale or donation to any person without the written authorisation of the Employer.

#### **A4.2.3.2 Contractor prepared plans for cuttings**

The Contractor shall prepare and submit a **Management and Utilisation (M&U) plan** of operations for every cutting where the quantity of cut material will exceed 5 000 m<sup>3</sup>. Only a representative M&U plan can be submitted for cuttings between 5 000 m<sup>3</sup> and 10 000 m<sup>3</sup> where the cuttings have significantly similar material classes and excavation methods. **Box cuts and designated excavations do not require M&U plans.**

The M&U plan for the cutting shall at least show and include the following:

- The curriculum vitae of the proposed materials manager, excavation and stockpile controllers as applicable;
- The survey methods to stake the cut lines and slopes;
- Demarcation of the areas for stockpiling of topsoil, overburden and the various fill and pavement layer materials as required;



- Sequence and working of the cutting for sourcing the material;
- The testing protocol of the applicable tests and the frequency of testing;
- A method statement and risk assessment for sourcing the material;
- Method statements for the blasting of hard material, details for the safe storage and transport of explosives and the process for obtaining blasting permits in terms of the requirements specified in Section A12.10 of Chapter 12;
- When blasting within the vicinity of buildings or structures, measures to comply with the relevant Act and Regulations pertaining to the utilisation of explosives, as specified in Clause A1.2.7.5 of Chapter 1, proposals for the examination and recording of the condition of the buildings and structures in Clause A1.2.3.13 of Chapter 1 and compliance with the specifications given in Clause A12.10.7.2 of Chapter 12;
- The finishing and stabilising of the cut slopes;
- The positioning of crushers, screens and other plant for crushing and screening of materials;
- Measures to comply with the conditions of the statutory road environmental approval;
- Measures to comply with safety regulations and obligations in terms of the relevant Health and Safety Acts and Regulations; and
- Procedures for regular monitoring, auditing and reporting.

M&U plans need only to be submitted **during the course of the construction**. However, no operations at a cutting including clearing and grubbing, shall commence until the Contractor's M&U plan for that cutting has been reviewed and accepted by the Engineer. **The Engineer shall respond within one week after receiving an M&U plan.**

## A4.2.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Not required for Section A4.2.

## A4.2.5 MATERIALS

### A4.2.5.1 General

The specifications given in Clause A4.1.5 shall also apply to cut materials and are the required specifications for the cut material as finally processed and constructed on the road.

### A4.2.5.2 Quality of materials

It is the **Contractor's responsibility** to ensure that the cut material including all operations such as excavation, loading, hauling, producing and stockpiling as applicable **will comply with the material specifications**, subject to the relevant provisions of the Contract Documentation.

**Monitoring the quality and quantity** of the cut materials produced for the construction on the road shall be the responsibility of the **Contractor**.

Based on a visual inspection by the Engineer and on the results of material tests as deemed appropriate, **the Engineer shall have the right to declare the material non-compliant for use at any time before construction on the road or stockpiling as applicable**. The Contractor shall then submit proposals for acceptance by the Engineer to rectify or replace the non-compliant material. **Acceptance control testing** of materials by the Engineer **shall only be carried out during or after construction on the road, or of the material in the stockpile as applicable**.

## A4.2.6 CONSTRUCTION EQUIPMENT

Construction equipment to source the cut materials shall comply with the requirements of Clause A1.2.6 of Chapter 1.

## A4.2.7 EXECUTION OF THE WORKS

### A4.2.7.1 Excavation operations

#### a) Control at the cuttings, designated excavations and box cuts

Control at the cuttings and the designated excavations shall be done in accordance with the requirements in Clause A4.1.7.2a) for borrow pits and quarries. Box cuts, being shallow excavations, do not require control of the excavation operations other than ensuring that the levels are correct and the quality of the box cut material complies with its designated usage, and that the quantity and wastage aspects are controlled.

When there is at any time any doubt concerning the quality of the cut material for its intended use, the Contractor shall notify the Engineer immediately before such material is brought onto the road or taken to stockpile. The results of all the tests conducted by the Contractor shall be submitted. After further testing or inspection as required and agreed to, the Contractor shall be instructed regarding the further use of the cut material.

When specified in the Contract Documentation, the Contractor shall have a full time or part time **materials manager** to conduct and manage the duties for the control at the excavations. The requirements for the materials manager, whether the person shall be an engineering geologist, engineer, a senior materials technician or a senior general foreman, and the required qualifications and experience of the materials manager, shall then also be specified.

#### b) Classes of excavation

**Excavation of material in a cutting, in a box cut and in a designated excavation shall be classed as soft, boulder or hard excavation in accordance with the classification in Clause A4.1.7.2b).**

**In the absence of any construction equipment specified in the Contract Documentation to reference the efficient removal of soft material**, the following equipment, all construction equipment to be in good mechanical order, shall be used to determine the efficiency (production rates hereunder refer to a continuous excavation production quantity of the in situ material):

- **In road cuttings** – a hydraulic crawler excavator with nett horsepower (flywheel power) generally between 180 kW and 225 kW, also known as a **30 ton excavator, and fitted with a heavy duty bucket**. A **minimum continuous production rate of 160 m³/h of the excavated material** will be taken as the benchmark for this excavator's capacity and efficiency. When this production rate cannot be achieved the material being excavated shall be classified as hard.
- **In box cuts and designated excavations of large or medium size projects where larger excavators form part of the Contractor's approved construction equipment** – a hydraulic crawler or wheel excavator with nett horsepower (flywheel power) generally between 100 kW and 150 kW, also known as a **20 ton excavator, and fitted with a general duty bucket** for excavation of box cuts and with a fish tail bucket for designated excavations. A **minimum continuous production rate of 100 m³/h of the excavated material** shall be taken for this excavator's capacity and efficiency. If this production rate cannot be achieved the material being excavated shall be classified as hard.
- **In box cuts and designated excavations of small projects where only small plant forms part of the Contractor's approved construction equipment**, a tractor-loader-backhoe (TLB), or a small or compact excavator with nett horsepower (flywheel power) generally less than 75 kW and **fitted with a general duty or general purpose bucket**. A **minimum continuous production rate of 30 m³/h of the excavated material** shall be taken as the capacity and efficiency of a TLB or a small or compact excavator. When this production rate cannot be achieved the material being excavated shall be classified as hard.

Excavation of material in existing roads of which the material is to be removed as part of the bulk excavation, shall also be classed in terms of this Clause. When the existing road material is removed in controlled layers, the excavation classes in Section A4.3 shall apply.

The Contractor shall be at liberty to use any method and construction equipment for excavating any class of material, but the chosen method or construction equipment to excavate the material shall not dictate the classification of the material.

Based on the information in the Contract Documentation, and further supplementary exploration during the contract as specified in Clause A4.2.7.1c), and a visual inspection if possible, and before any excavation commences, the Engineer and the Contractor shall agree on the applicable classes of excavation. Agreement shall also be reached on the method of measurement to be used for each class of excavation prior to the commencement of any excavation.

In the event of a disagreement between the Engineer and the Contractor, the Contractor shall if required, make available such reference construction equipment as specified at no cost to the Employer, in order to determine whether or not the material can be efficiently removed. The decision of the Engineer as to the classification shall thereafter be final and binding, subject to the relevant provisions of the Contract Documentation.

The Contractor shall immediately inform the Engineer when the nature of the material being excavated changes to such an extent that a new classification for further excavation is warranted. Failure to inform the Engineer of any possible change in the class of excavation before the material is excavated, shall entitle the Engineer to classify and measure such excavation as deemed appropriate.

#### c) Supplementary exploration

The Contractor, in the presence of the Engineer, shall **conduct further investigations** and obtain information for the M&U plan of every cutting where the **quantity of cut material exceeds 5 000 m³**, in accordance with the requirements of Clause A4.1.7.2c).

For **smaller cuttings and box cuts** the type of in situ material, the strength and indicator properties and the hardness of the material established during the design stage, must be verified with **further trial pits and subsequent laboratory testing**.

**Designated excavations** will not usually have been investigated during the design stage of the project. If some geotechnical investigation results are included in the Contract Documentation, it must only be regarded as indicative information that will require further confirmation. Supplementary exploration comprising **trial pits and material testing shall be conducted of every designated excavation** to prove that the material is compliant for use in the road or if it must be spoiled.

#### d) Clearing and grubbing

The top surface of a cutting, the widening or altering the side slope of an existing cutting, as well as the box cut and the designated excavation surfaces shall be cleared and grubbed as specified in Section A1.6 of Chapter 1.

The extent of the clearing and grubbing for cut materials shall be as follows:

- In **cuttings 1,0 m** wider than the cut line, cut off bank or drainage dyke as applicable.
- For **designated excavations 1,0 m** wider on either side of the excavation cut line.
- For **box cuts 0,5 m wider** on either side of the excavation cut line plus a strip for any sidewalk, if applicable.

For **clearing and grubbing of new developments in urban areas the Engineer shall instruct the extent** of the clearing and grubbing, namely for the full width of the road reserve or for only the width of the cutting or box cut as specified above.

In cuttings where the total thickness of the topsoil and the overburden is more than 1,0 m, all trees and tree stumps including mattered roots shall be removed to a depth of at least 1,0 m below the cleared surface. Where the total thickness is less than 1,0 m a separate grubbing operation is not required and the tree stumps can be removed together with the overburden, unless otherwise instructed by the Engineer.

In designated excavations and box cuts, trees and tree stumps including mattered roots shall be removed to 1,0 m below the cleared surface.

The removal of buildings and structures is specified in Section A1.6 of Chapter 1.

**The removal of materials generally found in urban areas such as road edging, services structures, and paved sidewalks are specified in Section 4.3.**

#### e) Removal and conservation of the topsoil

After clearing and grubbing the topsoil shall be excavated and stockpiled as specified in Section A1.6 of Chapter 1, for later use in the works.

#### f) Spoil material

Material in the cuttings, the box cuts and the designated excavations that is not compliant for the earthworks and pavement layers or material that is not required for further use shall be excavated, loaded and hauled directly to spoil sites. Only where designated spoil sites are not available at the time of spoiling, shall temporary stockpiles be permitted with prior consent of the Engineer.



#### g) Cleaning of the bedrock

Hard rock material in the excavations to be processed by crushing or crushing and screening, shall be cleaned of all loose and foreign material that may have remained from the topsoil and overburden, and that can affect the quality of the crushed rock.

#### h) Excavation of material in cuttings

The dimensions of cuts shall be in accordance with the details of the typical cross-sections as shown in the Contract Documentation, and shall further be defined or amended during the course of construction by instructions from the Engineer. The Contractor shall first obtain instructions from the Engineer regarding the slope of the sides of cuttings and the depth to which the cuttings are to be taken, including the dimensions of any in situ treatment of cuts that may be required.

No removal of overburden or any further cutting operations shall commence until agreement has been reached with the Engineer in regard to the thickness, the extent, use and quantity of the overburden. Overburden less than 200 mm thick shall be removed with the topsoil and not separately. Overburden that is not required for further use shall be excavated, loaded and hauled directly to spoil sites. Only where designated spoil sites are not available at the time of spoiling, shall temporary stockpiles be permitted with prior consent of the Engineer. Overburden required for later use shall be moved to beyond the outer limits of the cutting. This operation shall not be regarded as temporary stockpiling. The Engineer's approval must be obtained for removing and stockpiling of overburden that cannot be moved to beyond the limits of the cutting, or for overburden that is to be used in the works.

The Contractor shall take proper care when excavating material not to loosen any material outside the specified cut lines, whether by ripping, blasting or by other means that would endanger the stability of the cutting slopes or that would subsequently cause undue erosion or disintegration of the cutting slopes. This may entail modifying the methods of excavating when work is done in the vicinity of the final cut surface.

Care shall also be taken not to undercut any cutting slopes, and proper control shall at all times be exercised by regular survey checking and by using batter poles at maximum 10 m intervals. The final surface of cuttings in hard excavation shall generally not be more than 0,5 m below the specified cutting slope surface. Where the cutting slopes are nevertheless undercut and overbreak occurs, it shall be backfilled with imported compacted gravel material, soil cement or concrete. Where the imported material may not be considered an appropriate remedy, remedial measures may be ordered such as cutting back the entire or large sections of the cutting slope to a uniform slope, at the Contractor's expense.

For excavations in hard material the Contractor shall design the drilling pattern, depth and explosive charge load according to the nature of the material to achieve a stable cutting slope, at the specified slope with a minimum of overbreak. The Contractor shall not create loose unstable material outside the specified cutting slope due to poor blasting or construction techniques. In such an event the Contractor shall render the cutting slope stable by flattening or other approved methods at no cost to the Employer. When the nature of the material is such that an even cutting slope cannot be achieved by blasting due to rock slope movement or boulders protruding from the slope that may become loose, the Contractor shall inform the Engineer timeously that the overbreak is unavoidable and agreement shall be reached for compensation and backfilling, if any, of the overbreak.

Specialised slope protection measures shall be specified in the Contract Documentation. These works shall be carried out in accordance with the requirements and specifications in Section 12.9 of Chapter 12. When the Contractor is of the opinion that the nature or formation of the material or rock in the cutting is too unstable to achieve the specified cutting slope or that the slope protection measures may be insufficient, the Engineer shall be informed as soon as the unstable material becomes evident so that additional geotechnical measures can be implemented.

Benches shall be made in deep cuttings for maintenance and erosion prevention purposes, and in rock cuttings for stability purposes, in accordance with details in the Contract Documentation.

The excavation of mudrock (shale) formations require special attention to minimise overbreak. On account of its poor durability qualities, mudrock material from the excavation may not be appropriate for backfilling the overbreak and hence its use for this purpose may not be permitted.

The Engineer shall inspect the floor of the cutting as the bulk excavation proceeds, and shall instruct any additional deeper excavation to remove unsuitable material.

The material in the cuttings shall be **broken down to the following maximum particle sizes**, depending on the use envisaged for the material, before it is loaded:

- **Pioneer** material 500 mm.
- **Rockfill** 500 mm.
- **Coarse fill** 500 mm, but not exceeding the thickness of the fill layer for efficient compaction by the construction equipment.
- **Normal fill** 300 mm.
- **Pavement layers** 300 mm.
- **Material to be crushed**, the take of the crusher.

In order that the material can be broken down to the above-mentioned sizes, the Contractor shall adjust and control the blasting, ripping, excavating and other operations so that the desired result can be achieved. Drilling and blasting patterns shall be such as to break down the material to the specified sizes, and where this is impractical, secondary blasting or other methods shall be used for breaking down oversize materials.

Where the working methods of the Contractor are such that large quantities of oversize material are produced, the Contractor shall be instructed to change the working methods, or type of crushing and screening plant, or construction equipment in order to produce less oversize material.

Excessive breaking down of the finer fraction of the material and thereby altering the properties of the material shall be avoided. Any material so altered shall be replaced by the Contractor without any cost to the Employer.

When specified in the Contract Documentation, the Contractor shall have an excavation controller to manage the selection and excavation of the cut material. The requirements for the excavation controller, namely whether the person shall be a materials technician or a general foreman, the controller's required qualifications and experience, and whether the controller is to be present full time or only part time at the excavation, shall then also be specified.

#### i) Excavation of material in box cuts

The dimensions of box cuts shall be in accordance with the details of the typical cross-sections as shown in the Contract Documentation, and shall further be defined or amended during the course of construction by instructions from the Engineer. The Contractor shall first obtain instructions from the Engineer regarding the depth to which box cuts are to be taken, including any in situ treatment that may be required.

The **sides of box cuts shall be stepped** as shown in the Contract Documentation or as instructed by the Engineer. Where box cuts are made for the widening of existing roads, the Engineer shall give instructions about the cut back and tie-in to the existing layers, and for saw-cutting of the existing layers. **(Additional note: Details given in Clause A5.3.3.7b) of Section 5.)**

#### **j) Excavation of material in designated excavations**

Designated excavations shall be constructed true to line, grade and cross-section as shown to details in the Contract Documentation.

Excavation below the required grades shall be avoided, and any excavation beyond the required grade as a result of negligence or poor construction techniques shall be backfilled with compliant material and compacted as approved by the Engineer, at no cost to the Employer.

For excavations in hard material, the Contractor shall plan the removal of the hard material so that it results in a minimum of or no overbreak.

#### **k) Selection and use of the cut material**

The results of laboratory tests, trial pits and drilling on cut materials carried out during the design stage are included in the Contract Documentation. The results and other information in the Contract Documentation give a preliminary indication as to the purpose for which and where the cut material shall be used. The Engineer shall give final instructions during construction regarding the use of the cut material.

Cut material shall be selected at the excavation, whether for use in the earthworks or in the pavement layers or in appurtenant works, so that its usage is optimised. Compliant material shall not be excavated together with non-compliant material, unless it is impossible to separate the different classes of material.

Cut to fill material shall be excavated and loaded directly for use on the road. Only after approval, where there is insufficient work space on the road or where the excavation of the cut material cannot be postponed, shall the Engineer instruct that material be stockpiled temporarily. Material placed temporarily adjacent to a trench or excavation for later loading and removal shall not be classified as stockpiling.

The cut material for pavement layers shall be selected, excavated, removed and always placed into suitable separate stockpiles to provide a uniform material.

Coarse rock encountered shall be utilised for the construction of the lower layers of fills high enough to accommodate thick layers, or, where so required, shall be conserved and used as directed for constructing the sides of embankments or for serving as protection against embankment or channel erosion.

The Engineer may order that particular materials in road cuttings, box cuts and designated excavations be selected for a specific purpose. Where selection is ordered, the method of excavation and the programme of works shall be so arranged by the Contractor to avoid double handling. When ordered by the Engineer, the better class fill material shall be selected for use in the top layer of the fills and in the lower layers of high fills.

Any surplus or non-compliant material resulting from the excavations shall be disposed of as directed by the Engineer.

The Engineer shall have full control over the use of all cut material. The Contractor shall plan the operations and particularly the cut-to-fill operations in such a manner that all cut material is used to the best advantage of the Employer. This means that no material shall be unnecessarily spoiled, excavated, stockpiled or hauled. The Contractor shall neither excavate nor spoil any material without the Engineer's approval, and without proving to the Engineer that this is necessary and that it is the most economical method of constructing the works.

#### **l) Use and treatment of oversize material**

Excavated cut material that contains oversize material, that is material exceeding the specified maximum particle sizes in Clause A4.2.7.1h), shall be handled as follows:

- Where the material contains less than 5 % by volume of the oversize material, the material can be hauled to the road or placed in the stockpile. The oversize material shall then be broken down by using appropriate compaction rollers or bladed out of the layer or removed by hand on the road, and then later returned to the borrow pit or taken elsewhere as spoil material or to a crusher, if available, for crushing.
- Where the material contains more than 5 % by volume of oversize material the Engineer shall instruct before the material is loaded at the excavation whether all the material, including the non-oversize material, shall be crushed and/or screened or broken down on the road during construction or taken to spoil.

#### **m) Producing the material by blasting, crushing and screening**

The requirements for the control of blasting, and for producing material by crushing and screening of hard, boulder and oversize material in borrow pits and quarries as specified in Clauses A4.1.7.2j) and A4.1.7.2k) respectively, shall also apply for cut material.

#### **n) Finishing of the side slopes of cuttings and designated excavations**

The side slopes of cuttings (batters) and designated excavations shall be finished (or shaped and formed) as specified in the Contract Documentation or in the statutory road environmental approval. In the absence of any specified requirements, the minimum requirements listed below shall be complied with for the finishing. Additional finishing requirements for specialised slope protection measures are given in Section 12.9 of Chapter 12.

The side slopes of **road cuttings** shall be finished (or shaped) as follows:

- The slopes shall be finished to a standard which is generally achievable 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 smoothly into the other or into the natural ground without a noticeable break that can be readily discerned from the road,
- Slopes within soft material shall be finished to a slope not steeper than 1 vertical to 2 horizontal,
- In soft excavation all loose rocks, boulders and cobbles larger than 75 mm shall be removed and the final surface of the side slopes shall have a slightly roughened surface where it is to be topsoiled,
- Slopes in soft excavation shall be finished to within a tolerance of 100 mm above to 100 mm below the specified side slope line, with all undulations following a smooth line,
- Slopes in hard and boulder excavation shall be finished to remove all loose, unstable and unsafe material, and the slopes will generally not require subsequent topsoiling and grassing,
- Finishing work shall include any measures specified in the Contract Documentation to protect and stabilise unstable slopes,
- Except in solid rock, the tops and bottoms of all side slopes shall be rounded for a width of 1,0 m,
- Where grassing is to be carried out the side slopes shall receive a 75 mm to 150 mm thick topsoil layer, and
- Cut off drains and/or banks shall be constructed at the top of all cut slopes where the natural ground above the cutting slopes towards the cutting.

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

The minimum requirements for finishing or shaping the side slopes of **designated excavations** are:

- The side slope shall be profiled to suit the specified dimensions and slopes of the structure for which the excavation has been made,
- All loose rocks, boulders and cobbles must be removed, as well as any protruding hard rock,
- Overbreak or over excavation shall be backfilled with stabilised material, soil cement or concrete,
- The surface of soft excavation shall be firm and loose material shall be compacted,
- Excavation lines for unlined designated excavations shall be finished to within a tolerance of 50 mm above to 50 mm below the required levels, and
- Excavation levels for designated excavations that will receive a lining shall not be 25 mm higher or lower than the levels required for the lining.

#### **A4.2.7.2 Stockpiles**

The preparation of the stockpile site, stockpiling of the material and reinstatement of the stockpile site shall be done in accordance with the requirements of Clause A4.1.7.3.

Unless the material being obtained from cuttings, box cuts and designated excavations is very variable a full time stockpile controller is not necessarily required.

#### **A4.2.8 WORKMANSHIP**

The Engineer and the Contractor shall determine and agree on the testing protocol and frequency of the applicable process control tests required for each type of the sourced cut materials to ensure that the quality of materials produced meets the specified requirements for the particular layer for which it will be used. These required laboratory tests and testing frequencies shall be stated in the cutting M&U plans.

Measurement, testing, and evaluation of all individual components and constructed products shall be in accordance with the methods prescribed in this Section or in Chapter 20 as relevant.

## C4.2 CUT MATERIALS

### 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 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 the items describing the activity or in other items as deemed appropriate:

1. Excavation or undercut outside the specified dimensions or limits or the cutting slopes of the cuttings and excavations.
2. Backfill or cutting back the slope to remedy the overbreak or undercut that is caused by neglect, poor workmanship or inadequate supervision and management by the Contractor.
3. Removal of any material that has become unstable due to the Contractor's poor or inappropriate excavation and/or blasting methods, or any work and materials required to remedy the unstable areas.
4. Spoil of oversize material due to poor blasting or construction techniques.

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

For activities in Table C4.2-1 items specified in other Sections of the specification, where they relate to work under this Section, will be listed in the Pricing Schedule.

**Table C4.2-1: Payment items from other Chapters or Sections**

Activity	Section 4.2 reference	Section item reference
Clearing, grubbing, removal of large trees, and removal of buildings and structures	A4.2.7.1d) and A4.2.7.2	C1.6.1 to C1.6.4 of Chapter 1
Conservation (excavating and stockpiling) of topsoil (including overburden less than 200 mm thick)	A4.2.7e)	C1.6.9 of Chapter 1
Blasting of hard material	A4.2.7.1m)	C12.10.1 of Chapter 12
Producing the material by crushing and screening	A4.2.7.1m)	Section C4.1 of Chapter 4 - All applicable items
Placing of topsoil, and vegetation	A4.2.7.1n)	Section C11.8 of Chapter 11 - All applicable items
Stockpiling the material	A4.2.7.2	Section C4.1 of Chapter 4 - All applicable items
Hauling material (when applicable)	A4.2.7.1 and A4.2.7.2	C1.7.2 of Chapter 1

#### (iv) Items specifically for this Section of the specifications

Item	Description	Unit
<b>C4.2.1</b>	<b>Compiling and implementing M&amp;U plans for the cuttings</b>	
C4.2.1.1	Cuttings exceeding 5 000 m <sup>3</sup> up to 10 000 m <sup>3</sup>	number (No)
C4.2.1.2	Cuttings exceeding 10 000 m <sup>3</sup> up to 20 000 m <sup>3</sup>	number (No)
C4.2.1.3	Cuttings exceeding 20 000 m <sup>3</sup> up to 50 000 m <sup>3</sup>	number (No)
C4.2.1.4	Cuttings exceeding 50 000 m <sup>3</sup> up to 100 000 m <sup>3</sup>	number (No)
C4.2.1.5	Cuttings larger than 100 000 m <sup>3</sup>	number (No)

The volume referred to in the description shall be the total volume of material in place that must be removed. It includes the volume of topsoil and overburden, the material compliant for earthworks and pavement layers and any spoil material.

The unit of measurement shall be the number of cuttings for which M&U plans have been compiled. A distinction shall be made between the various cuttings based on the total volume of material to be excavated in the cutting. When several cuttings between 5 000 m<sup>3</sup> and 10 000 m<sup>3</sup> are covered by a representative M&U plan they shall all be measured together as one plan.

The tendered rates shall include full compensation for gathering all information and compiling the plans, except for the additional material investigations agreed to by the Engineer that will be measured and paid separately, and to ensure implementing the plans during the operation of the cutting.

Item	Description	Unit
<b>C4.2.2</b>	<b>Additional material investigations during the supplementary exploration</b>	
C4.2.2.1	Cost of additional trial pits and/or drilling and laboratory testing	provisional sum
C4.2.2.2	Handling costs and profit in respect of item C4.2.2.1	percentage (%)

Item	Description	Unit
<b>C4.2.3</b>	<b>Excavating of materials in cuttings, material obtained from</b>	
C4.2.3.1	Soft excavation	cubic metre (m <sup>3</sup> )
C4.2.3.2	Boulder excavation class A	cubic metre (m <sup>3</sup> )
C4.2.3.3	Boulder excavation class B	cubic metre (m <sup>3</sup> )
C4.2.3.4	Hard excavation (other than by blasting)	cubic metre (m <sup>3</sup> )
C4.2.3.5	Hard excavation (by blasting)	cubic metre (m <sup>3</sup> )
Item	Description	Unit
<b>C4.2.4</b>	<b>Excavating of materials in box cuts, material obtained from</b>	
C4.2.4.1	Soft excavation	cubic metre (m <sup>3</sup> )
C4.2.4.2	Boulder excavation class A	cubic metre (m <sup>3</sup> )
C4.2.4.3	Boulder excavation class B	cubic metre (m <sup>3</sup> )
C4.2.4.4	Hard excavation (other than by blasting)	cubic metre (m <sup>3</sup> )
C4.2.4.5	Hard excavation (by blasting)	cubic metre (m <sup>3</sup> )
Item	Description	Unit
<b>C4.2.5</b>	<b>Excavating of materials in designated excavations, material obtained from</b>	
C4.2.5.1	Soft excavation	cubic metre (m <sup>3</sup> )
C4.2.5.2	Boulder excavation class A	cubic metre (m <sup>3</sup> )
C4.2.5.3	Boulder excavation class B	cubic metre (m <sup>3</sup> )
C4.2.5.4	Hard excavation (other than by blasting)	cubic metre (m <sup>3</sup> )
C4.2.5.5	Hard excavation (by blasting)	cubic metre (m <sup>3</sup> )

The unit of measurement for items C4.2.3, C4.2.4 and C4.2.5 shall be the cubic metre of material excavated for use on the road.

**The volume shall be measured in place in its original position in the cutting, box cut or designated excavation.** It shall be calculated from the difference between levels taken on topographical surveys carried out after the removal of the topsoil, and from levels taken on surveys done after completion of the excavation of the different material classes. **The volume of classified unavoidable overbreak in hard or boulder material shall be included in the measurement.**

For boulder material, the Engineer may approve that the quantities be measured in haul vehicles as an alternative when the boulder material cannot be identified accurately prior to excavating, by taking the in situ volume of the boulder material as equal to 50 % of the loose volume of the material in the haul vehicles.

The tendered rates for items C4.2.3, C4.2.4 and C4.2.5 shall include full compensation for breaking down the cut materials in the various classes to the specified maximum particle sizes, for excavating, and loading the material. Should the Contractor choose for designated excavations to temporarily place the excavated material next to the excavation for loading later, it shall not be considered as stockpile of material nor shall the loading be considered as a separate activity for compensation.

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 of Chapter 12.

The excavating and disposing of unsuitable and spoil material shall be measured and paid for under item C4.2.7 and under item C4.2.8 or C4.2.9 as applicable.

Item	Description	Unit
<b>C4.2.6</b>	<b>Widening of existing cuttings</b>	
C4.2.6.1	Soft excavation	cubic metre (m <sup>3</sup> )
C4.2.6.2	Boulder excavation class A	cubic metre (m <sup>3</sup> )

C4.2.6.3	Boulder excavation class B	cubic metre (m <sup>3</sup> )
C4.2.6.4	Hard excavation (other than by blasting)	cubic metre (m <sup>3</sup> )
C4.2.6.5	Hard excavation (by blasting)	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material excavated during the widening of existing cuttings.

Widening of existing cuttings shall be a widening more than 2,5 m deep (measured vertically from the top of the cutting to the shoulder breakpoint), and where the cutting is widened by less than 4,0 m. Widening of existing cuttings larger than these dimensions shall be measured and paid for under item C4.2.3.

Measurement of the material shall be in place in the original position in the cutting, and the quantity shall be computed by the method of average end areas from surveyed cross-sections at intervals not exceeding 20 m measured along the centre line of the road or from topographical surveys, before and after removal of the material.

For boulder material, the Engineer may approve that the quantities be measured in haul vehicles as an alternative when the boulder material cannot be identified accurately prior to excavating, by taking the in situ volume of the boulder material as equal to 50 % of the loose volume of the material in the haul vehicles.

The tendered rates shall include full compensation for breaking down the various classes to the specified maximum particle sizes, excavating, and loading the material.

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 of Chapter 12.

Item	Description	Unit
<b>C4.2.7</b>	<b>Removal of unsuitable stable cut material to spoil</b>	
C4.2.7.1	In layer thicknesses of 200 mm and less	cubic metre (m <sup>3</sup> )
C4.2.7.2	In layer thicknesses exceeding 200 mm	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material removed to spoil in accordance with the Engineer's instructions.

The volume shall be measured in place in its original position and shall be calculated in accordance with the authorized dimensions.

The tendered rates shall include full compensation for excavating and loading the material in the floor of the excavation, and for disposing the material. Payment under this item shall only be made when the material is removed in a separate excavation operation after the bulk excavation is completed on instruction by the Engineer, else the material shall be classified as spoil material and then measured and paid for under item C4.2.8 or C4.2.9 as applicable.

Haul shall be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.2.8</b>	<b>Excavate material to spoil in sites designated by the Employer, material obtained from</b>	
C4.2.8.1	Soft excavation, overburden and unsuitable material	cubic metre (m <sup>3</sup> )
C4.2.8.2	Boulder excavation class A	cubic metre (m <sup>3</sup> )
C4.2.8.3	Boulder excavation class B	cubic metre (m <sup>3</sup> )
C4.2.8.4	Hard excavation (other than by blasting)	cubic metre (m <sup>3</sup> )
C4.2.8.5	Hard excavation (by blasting)	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material excavated and spoiled.

The quantities shall be measured in place in its original position in the cutting, box cut or designated excavation, and shall be computed from topographical surveys. The Engineer may approve that the quantities be measured in the haul vehicles as an alternative when the quantities of the spoil material cannot be calculated accurately prior to excavating, by taking the in situ volume of the material in the case of soft excavation as equal to 70 % of the loose volume of material in the haul vehicles, and in the case of boulder and hard material as equal to 50 % of the loose volume of material in the haul vehicles.

The tendered rates shall include full compensation for breaking down the various classes to sizes required for hauling, excavating and loading, and for off-loading and disposing the material, including shaping and levelling-off any heaps of spoil material.

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 of Chapter 12.

Haul shall be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.2.9</b>	<b>Excavate material to spoil in sites designated by the Contractor, material obtained from</b>	
C4.2.9.1	Soft excavation, overburden and unsuitable material	cubic metre (m <sup>3</sup> )
C4.2.9.2	Boulder excavation class A	cubic metre (m <sup>3</sup> )
C4.2.9.3	Boulder excavation class B	cubic metre (m <sup>3</sup> )
C4.2.9.4	Hard excavation (other than by blasting)	cubic metre (m <sup>3</sup> )
C4.2.9.5	Hard excavation (by blasting)	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material excavated and spoiled.

The quantities shall be measured in place in its original position in the cutting, box cut or designated excavation, and shall be computed from topographical surveys. The Engineer may approve that the quantities be measured in haul vehicles as an alternative when the spoil material cannot be identified accurately prior to excavating, by taking the in situ volume of the material in the case of soft excavation as equal to 70 % of the loose volume of material in the haul vehicles, and in the case of boulder and hard material as equal to 50 % of the loose volume of material in the haul vehicles.

The tendered rates shall include full compensation for negotiations with the landowner or legal occupant of the property or of the spoil site, for breaking down the various classes to sizes required for hauling, excavating, loading and hauling the material to the spoil sites irrespective of the haul distance, for off-loading and disposing the material, and for finishing the spoil site and obtaining the approval of the property or spoil site owner, if applicable.

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 of Chapter 12.

The tendered rates shall also include the cost of spoiling at a municipal site, if applicable.

All haul costs shall be included in the tendered rates of item C4.2.9.

Item	Description	Unit
<b>C4.2.10</b>	<b>Backfilling of the unavoidable overbreak in hard and boulder excavation</b>	
C4.2.10.1	Compliant gravel material	cubic metre (m <sup>3</sup> )
C4.2.10.2	Soil cement (stiff mix with 3 % cement)	cubic metre (m <sup>3</sup> )
C4.2.10.3	Soil cement (wet mix with 5 % cement)	cubic metre (m <sup>3</sup> )
C4.2.10.4	Concrete class 15 MPa	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material used in the backfilling.

The quantities shall be measured from the quantity of material placed in the overbreak.

The tendered rates shall include full compensation for providing the material, and for placing, backfilling and compacting the material in the overbreak.

Payment for backfilling of overbreak shall only be made when the Engineer approves that the overbreak was unavoidable.

Item	Description	Unit
<b>C4.2.11</b>	<b>Breaking down oversize material</b>	<b>cubic metre (m<sup>3</sup>)</b>

The unit of measurement shall be the cubic metre of oversize material that is broken down.

The quantity shall be measured by the volume of individual boulders or lumps of hard material. Where material is moved for breaking down the Engineer may approve that the quantity be measured by taking the volume to be equivalent to 50 % of the loose volume in the haul vehicles of the material to be broken down, as an alternative to measuring the individual volumes.

Breaking down of the cut material to the specified maximum particle sizes in Clause A4.2.7.1h) during the excavation operation or on the road by construction equipment shall not be measured under this item. Only further breaking down by conventional construction equipment of oversize cut material, as instructed or approved by the Engineer, shall be measured and paid.

The tendered rate shall include full compensation for breaking down the material.

No distinction shall be made between various methods of breaking down the oversize material.

No haul shall be paid where oversize material must be moved for breaking down.

Item	Description	Unit
<b>C4.2.12</b>	<b>Finishing the side slopes</b>	
C4.2.12.1	Cuttings:	
(a)	In soft material	square metre (m <sup>2</sup> )
(b)	In boulder material class A and B	square metre (m <sup>2</sup> )
(c)	In hard material	square metre (m <sup>2</sup> )
(d)	In soft material using labour enhanced methods of construction	square metre (m <sup>2</sup> )
C4.2.12.2	Designated excavations	square metre (m <sup>2</sup> )
C4.2.12.3	Designated excavations using labour enhanced methods of construction	square metre (m <sup>2</sup> )

The unit of measurement for cuttings shall be the square metre of the finished side slope areas.

The unit of measurement for designated excavations shall be the square metre of the side slope areas and the floor (invert) area where applicable.

The areas shall be measured from topographical surveys, or from tape measurements at 5,0 m cross section intervals where accurate tape measurements can be undertaken.

The tendered rates for finishing shall include full compensation for finishing the side slopes, and for loading, hauling and disposing of any excess material arising or brought down during the finishing operations. Placing of topsoil and vegetation shall be measured and paid separately.

Any haul costs shall be included in the tendered rates of item C4.2.12.

Specialised slope protection measures shall be measured and paid in Section 12.9 of Chapter 12.

# QUESTIONS?

# BREAK!



## **1.6. Section 4.3 - Existing Road Materials**

## 4.3 EXISTING ROAD MATERIALS

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## A4.3 EXISTING ROAD MATERIALS

### PART A: SPECIFICATIONS

#### A4.3.1 SCOPE

This Section covers the work requirements for sourcing of existing road construction materials that are:

- Obtained from reclaiming or from the reconstruction of existing road fills, pavement layers and asphalt materials.
- Used to reconstruct the same road they are obtained from or used on another road project.

This Section also covers the removal of existing concrete pavements and paving blocks from the road, and of materials in urban areas such as road edging, services structures, and paved sidewalk materials.

Chapter 5 – Earthworks and Pavement layers: Construction, covers the construction of the road layers.

#### A4.3.2 DEFINITIONS

The relevant definitions in Chapter 1 and Clause A4.1.2 shall also be applicable to this Section. Additional definitions for this Section are listed below.

**Cemented material** - also referred to as bound material, is existing stabilised or treated road layer material that can only be removed by milling, or by pulverising prior to excavation by using conventional road construction equipment.

**Milling** - a process to break down (pulverise) and remove, all or part of bituminous surfacing layers (seals and asphalt), and/or pavement layers by a milling machine.

**Reclaimed road materials** - are obtained by breaking up and excavating material in controlled separate layers from the existing earthworks and pavement layers and bituminous surfacing layers, producing compliant material by crushing and/or stockpiling it if required, and then hauling or moving it for use elsewhere on the same road, or on another road project or for other construction purposes.

**Reconstructed road materials** - are existing layer and bituminous surfacing materials that are scarified or pulverised (broken down) by ripping or broken down by a recycling machine and then subsequently processed in situ, for the construction of reconstructed road pavement layers.

**(Additional note: 1. This Section and pay items are very much focused on the urban environment. 2. No M&U plan for the works in this Section.)**

#### A4.3.3 GENERAL

##### A4.3.3.1 Employer identified existing road materials

The road layer information provided in the Contract Documentation for the existing layers reflects the results of trial pits and laboratory tests conducted by or on behalf of the Employer. This information is indicative of the type of road layer materials and layer thicknesses. The provision of this information shall not in any way be construed as defining or limiting the extent and thickness of materials nor the quality to be obtained from the existing road.

The use of existing road materials shall be specified in the Contract Documentation. These materials could be re-used on their own or mixed and blended with additional imported material or used with material from underlying layers or a combination of the above in order to increase the new layer thickness, or improve the material properties, or a combination of both requirements for the intended use of the material in the road.

#### **A4.3.3.2 Contractor identified materials**

Should the Contractor wish to propose alternative reclaiming or recycling methods, or use different materials or different proportions of materials, then a method statement shall be provided by the Contractor. The method statement shall be supported by sufficient test results and shall confirm that the Contractor's proposal will meet the Employer's requirements. When accepted, the Contractor's alternative methods and/or identified materials shall then be handled as an alternative in terms of the conditions of contract.

#### **A4.3.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS**

Not required for Section A4.3.

#### **A4.3.5 MATERIALS**

##### **A4.3.5.1 Reclaimed and reconstructed gravel and crushed stone materials**

The specifications given in Clause A4.1.5 for the materials shall also apply to reclaimed and reconstructed gravel and crushed stone materials.

The material requirements for stabilised materials are given in Table A4.4.5-2, and for bitumen stabilised materials in Table A4.4.5-3.

These material specifications are the required specifications for the reclaimed or reconstructed material finally processed and constructed on the road. The Contractor may be instructed to modify or blend reclaimed or reconstructed material by the addition of some imported material and/or treatment agents in order to produce a material that complies with the specified material properties.

##### **A4.3.5.2 Reclaimed asphalt material**

Asphalt material from existing surfacing or base layers may be removed to spoil or reclaimed for use.

Reclaimed asphalt from a surfacing and/or base layer may be used in the construction of earthworks, new pavement layers, recycled pavement layers or placed on the road shoulders. It may also be used as reclaimed asphalt in new asphalt layers, or for a wearing course of an unsealed road. The Contract Documentation shall specify where and in what mix proportions, if any, the reclaimed asphalt shall be used.

##### **A4.3.5.3 Bituminous seal surfacings**

Thin bituminous seal surfacings shall be processed together with the underlying layer during reconstruction, or shall be removed by blading or milled off before being taken to spoil, or shall be treated as reclaimed material if compliant for further use as specified in the Contract Documentation or instructed by the Engineer.

##### **A4.3.5.4 Quality of materials**

It is the Contractor's responsibility to ensure that the processed reclaimed or reconstructed materials resulting from all operations such as milling, pulverising, excavating, stockpiling, loading and hauling operations as applicable shall comply with the required material specifications, subject to the relevant provisions of the Contract Documentation.

#### **A4.3.6 CONSTRUCTION EQUIPMENT**

##### **A4.3.6.1 General**

Construction equipment to source the existing road materials shall comply with the requirements of Clause A1.2.6 of Chapter 1.

##### **A4.3.6.2 Milling machine**

The milling machine shall be capable of milling out either bituminous surfacing layers or unstabilised/stabilised pavement layer materials, or a combination of both simultaneously, to the depth specified in the Contract Documentation or as instructed by the Engineer.

The direction and speed of the milling machine and the speed of rotation of the milling drum shall be adjustable to deliver the required material properties. The machine shall be capable of making a neat vertical cut at the outer edges when milling. The Contractor shall inspect the milling machine's cutting tools, also known as picks, regularly and replace them as required whenever uneven or ineffective milling occurs, or when the gradation of the milled material is adversely affected.

The milling machine shall be equipped with a self-loading conveyor belt which can be easily removed and installed, and adjusted for slope and direction.

##### **A4.3.6.3 Construction equipment for breaking down and excavation**

The type of construction equipment to be used for the breaking down and excavation of existing pavement layers shall be determined by the size and depth of the pavement section to be excavated, taking into consideration that the work is sometimes carried out in restricted areas confined to only the demarcated areas of the pavement layers to be broken up.

#### **A4.3.7 EXECUTION OF THE WORKS**

##### **A4.3.7.1 Reconstructed layers**

The construction of reconstructed layers, including the breaking down and/or pulverising of the layers and then reconstructing it with or without modification, is covered in Section 5.5 of Chapter 5.

##### **A4.3.7.2 Supplementary exploration**

The Contractor, in the presence of the Engineer, shall conduct further investigations to confirm the quality, thickness, properties and quantity of the material of the existing road layers, that have been identified for reclaiming or reconstruction in the Contract Documentation.

Where it is intended to separately remove the asphalt layers in the existing pavement, investigations shall be carried out to determine the following:

- Potential quantity of the asphalt available for reclaiming,
- The haul distance to the nearest asphalt mixing plant with recycling capability,
- Locating a suitable area for stockpiling the reclaimed asphalt to suit the future recycling on other projects if applicable,
- Basic asphalt mix types in the existing pavement,
- Uniformity of the asphalt in the existing pavement layers,
- Visual condition of the pavement, and
- Ownership of the reclaimed asphalt.

Samples of asphalt layers shall be taken by at least 150 mm diameter cores or by using a small milling machine. The asphalt material shall be examined to establish:

- The thickness of each asphalt layer found in the core or in the excavation side face,
- The asphalt mix types in single or multiple layers,
- The presence of surfacing seals, particularly those containing highly modified binders,
- The presence of coal tar that can normally be detected by its pungent odour, and that will classify the material as hazardous and non-compliant for use as reclaimed asphalt,
- The presence of geosynthetic or other types of asphalt reinforcement interlayers, and
- For signs of stripping of the binder from the aggregate.

Trial pits in the road layers, or coring in cemented layers shall be made to depths as instructed by the Engineer. Sufficient trial pits or coring shall be made so that uniform material sections can be identified.

#### A4.3.7.3 Classes of excavation for reclaimed material

The **classes of excavation of reclaimed material** shall be classed according to the type of material being reclaimed, namely:

- **Asphalt material**, including bituminous surfacing seals thicker than 30 mm.
- **Crushed stone and macadam** materials.
- **Cemented** (chemically stabilised) material.
- **Natural gravel and sand** materials in the pavement layers and earthworks.
- **Coarse and rock fill** materials.

The **removal of road material not excavated in controlled layers** shall be classed as for **box cuts and designated excavations** in terms of Clause A4.2.7.1b) in Section 4.2.

#### A4.3.7.4 Milling

Before milling may be commenced, the surface of the existing road shall be cleaned of all vegetation, dirt, recent fuel spillage, road studs and any other foreign material.

Where the milled material is to be re-used in road pavement layers, the Contractor shall execute trial milling on the various materials to be milled. Trial milling shall consist of milling one strip not longer than 40 m. Trial milling shall not be required for material that is to be milled to spoil or re-used for general filling purposes. During the trial milling, the Contractor shall vary the speed of the milling machine, the speed of rotation of the milling drum and the milling depth, to select the desired optimum milling operation parameters to provide the required material quality and to prove that the milling machine is fit for purpose. The Engineer shall instruct the depth of milling the layer(s) after the trial milling.

Care shall be exercised to avoid damage to any concrete elements such as bridge expansion joints and joint nosings, manholes, kerbing, kerb inlets and any other roadside furniture during the milling and the excavation. Damage caused to any element forming part of the permanent works shall be repaired at no cost to the Employer.

The floor of a milled excavation shall have an even texture without any loose local areas. Loose areas shall be remedied as specified in the Contract Documentation or as instructed by the Engineer.

The floor of a milled excavation shall be tested in the longitudinal direction with a 3,0 m straight-edge, and in other directions with a straight-edge of such length as fits between the longitudinal sides of the excavation. The surface of the milled area shall not deviate by more than 7,0 mm from the bottom edge of the straight-edge.

#### A4.3.7.5 Safety at milled excavations

Milled excavations shall not be trafficked unless it is necessary to temporarily accommodate traffic. When shallow milled excavations need to be opened to traffic then all loose material shall first be removed, and all longitudinal and transverse joints caused by the milling excavation shall be tapered where the difference in level between the floor of the milled excavation and the existing road surface exceeds 25 mm. **Transverse joints shall be tapered at a slope of 1,0 mm vertical to 20,0 mm horizontal. Longitudinal joints shall be tapered at a slope of 1,0 mm vertical to 5,0 mm horizontal.** The tapers shall either be formed by cutting back the joint edges to the specified slope or by constructing a suitable asphalt wedge, which shall be bonded to the cleaned joint with a bituminous bond coat.

#### A4.3.7.6 Removal of asphalt material

Reclaimed asphalt material shall be removed separately from the existing road, either by excavating and breaking down the asphalt material into blocks using conventional road building equipment, or by milling off the asphalt material.

Where only part of the asphalt is to be milled off, the area to be milled shall be demarcated and the milling depth shall be specified. Milling shall not exceed the demarcated width by more than 50 mm or the specified depth by more than 5,0 mm.

Where the asphalt consists of layers of various mixes or grades, the results of the supplementary investigation will assist in deciding on the most appropriate milling strategy, namely whether to mill different asphalt layers separately (split milling), or to mill multiple asphalt layers together, or selective milling of non-compliant layers that must be discarded.

Contamination of the asphalt with underlying material, or unwanted damage to the underlying layer, during milling shall be avoided. The Contractor shall adjust and carefully control the depth of milling to prevent this by full time monitoring of the milled floor behind the milling machine.

Where the material is contaminated by the actions of the Contractor, it shall be replaced with other approved material at no cost to the Employer.

#### **A4.3.7.7 Excavation of crushed stone, macadam, cemented and gravel materials**

The existing pavement material shall be ripped or pulverised to the specified depth and then excavated using conventional road building equipment or by milling. The underlying layers shall not be damaged. Different types of material in consecutive layers may not be mixed unless required, and the Contractor shall adjust the depth of ripping, pulverising or milling in accordance with the thickness of the layer. Continuous adjustment will be required to suit any variations in the thickness of the pavement layer. Where unauthorised mixing occurs or where the material is contaminated in any other way by the actions of the Contractor, it shall be replaced with other approved material at no cost to the Employer.

Where a layer or layers required to be excavated over part of the road width only, the limit of the work shall be clearly demarcated and shall not be exceeded by more than 100 mm. Saw-cutting along the demarcated setting out line prior to excavation is obligatory, except where the material is removed by milling.

Excavation outside the demarcated limits shall be repaired by the Contractor at no cost to the Employer.

When specified in the Contract Documentation, the Contractor shall have an **excavation controller** to manage the selection and excavation of the pavement materials. The requirements for the excavation controller, namely whether the person shall be a materials technician or a general foreman, the controller's required qualifications and experience, and whether the controller is to be present full time or only part time at the excavation of the reclaimed pavement materials, shall then also be specified.

#### **A4.3.7.8 Removal of existing concrete**

The thickness of existing concrete road pavements or paving shall be established by core drilling prior to removal. Sidewalk or driveway concrete pavements do not need to be cored.

**The existing concrete shall be removed by one of two methods:**

- The break-up method, or
- The lift-out method.

The break-up method comprises breaking of the concrete with hand operated pneumatic or electro-mechanical equipment such as jackhammers or pavement breakers, or high energy impact compaction rollers, and removing it with a front end loader or a tractor-loader-backhoe (TLB) or by labour enhanced methods. Breaking out may be assisted by additional intermediate saw-cuts. In road pavements the breaking operation shall commence from the centre of the concrete pavement towards the boundary saw cuts to eliminate damage to any adjoining slabs. Care shall be taken with this method to avoid damage to the subbase if it is not to be reclaimed or recycled.

The lift-out method requires lifting hooks to be attached to the saw-cut slab and heavy lifting plant to lift out the concrete. Alternatively, the slab may be sawn into smaller pieces so that it can be lifted out by a front end loader or TLB. Although this method is less likely to damage the subbase and adjacent slabs, the Contractor is required to dispose of large slabs of concrete.

Where concrete is to be removed over part of the road width only, the limit of the work shall be clearly demarcated. Saw-cutting along the demarcated setting out line is obligatory. Removal of existing concrete outside the demarcated limits shall be repaired by the Contractor at no cost to the Employer.

#### **A4.3.7.9 Removal of existing paving blocks**

Existing paving blocks shall be lifted and used as specified in the Contract Documentation and/or instructed by the Engineer. Paving blocks that are to be handed to a property or landowner or are to be stockpiled for re-use shall be lifted by hand only. Paving blocks removed to spoil can be lifted by construction equipment.

Where paving blocks are to be handed to a property or landowner, the Contractor shall mark paving blocks that are broken or chipped and indicate them to the property or landowner prior to lifting of the blocks. The blocks shall be neatly stacked in a location agreed with the owner.

Paving blocks marked or instructed by the Engineer for re-use or other purposes, shall be removed to stockpile, and then neatly stacked.

Paving blocks that must be handed to a property or landowner, or that will be stockpiled for re-use, shall be cleaned of dirt, soil, concrete spillage and the like.

The bedding sand shall be removed after lifting of the paving blocks.

#### **A4.3.7.10 Removal of the existing road edging**

Existing road edging, such as in situ concrete kerbing and edge beams, precast kerbing, kerb inlets (catchpits), grid inlets and so forth, shall be demolished and removed to spoil at an approved spoil site provided by the Contractor, or shall be stockpiled and stacked for re-use as instructed by the Engineer.

#### **A4.3.7.11 Saw-cutting**

When specified or instructed that existing pavement layers are to be saw-cut, the equipment shall be capable of saw-cutting the pavement layers in a single operation without fragmenting the material, and in straight lines. The depth of saw-cutting shall be specified in the Contract Documentation or instructed by the Engineer. Requirements for saw-cutting and the construction of joints between existing and new layers are specified in Clause A5.3.3.7 of Chapter 5.

#### **A4.3.7.12 Stockpiling of material**

Should the reclaimed material have to be stockpiled, the requirements for stockpiles in Clause A4.1.7.3 shall apply. Stockpile sites shall be large enough to allow the placing of different types of material without the stockpiles overlapping.

**a) Preparation of the stockpile site**

Stockpile sites shall be prepared in accordance with the requirements of Clause A4.1.7.3a).

When specified in the Contract Documentation or instructed by the Engineer, the floor for the reclaimed asphalt stockpile site shall be stabilised to a depth of 150 mm. (Additional note: Stabilised so that water does not soak into the material underneath the stockpile, and to prevent groundwater contamination and contamination of the RA with the underlying material.)

**b) Stockpiling of the material**

Different types of material shall be stockpiled separately. When instructed by the Engineer, the Contractor shall remove the reclaimed asphalt material obtained from split milling to separate stockpiles.

Stockpiles of unprocessed reclaimed asphalt shall be ramp shaped and lifted in layers. When flattening the tipped material, it shall not be pushed over the edge to cause segregation. Stockpiles of unprocessed reclaimed asphalt shall not be covered, except when instructed by the Engineer.

Additional stockpiling requirements for reclaimed asphalt and for stockpiling of pavement layer materials are listed in Clause A5.5.5.2 of Chapter 5.

### **A4.3.7.13 Spoil of material**

Material from the milling and/or excavations of existing road materials that is non-compliant for the earthworks and pavement layers or material that is not required for further use shall be loaded and hauled directly to approved spoil sites.

Paving blocks, and road edging not suitable for further use or that are not required in future construction shall be loaded and hauled to approved spoil sites. Services structures, and asphalt and concrete material on sidewalks in urban areas shall also be spoiled.

Spoil sites are to be identified by the Employer or by the Contractor.

### **A4.3.8 WORKMANSHIP**

The material properties of the existing road layers shall always be verified by drilling of cores or by additional trial pits in the road and by subsequent laboratory testing, before any milling and/or excavation is carried out. The depths of the core drilling and trial pits and applicable laboratory tests shall be determined by the intended use of the material in the existing road, whether the material is to be reclaimed or recycled.

Testing shall be more comprehensive for recycling of layers. The effects of patching and repairs, the variable thickness of layers and the variable addition of new material may result in the fluctuation of material properties. The impact of the fluctuation of these properties must be properly managed.

For the recycling of asphalt and/or bound (stabilised) materials, slabs of the materials shall be removed from the road trial pits and then crushed manually or with a small laboratory crusher to simulate the material produced by the recycler.

Agreement shall be reached with the Engineer on the testing, protocol of the applicable tests and frequency of process control testing on the existing road materials, to ensure that the quality of the materials meets the specified requirements for the particular layer for which it will be used.

Measurement, testing, and evaluation of all individual components and constructed products shall be in accordance with the methods prescribed in this Section or in Chapter 20 as relevant.

## C4.3 EXISTING ROAD MATERIALS

### 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 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.

Loading of the reclaimed material on the existing road and hauling it for use elsewhere shall be measured in Chapter 5.

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

There are no activities in Section A4.3 that will not be measured and paid separately and for which the cost must be included in other items.

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

For activities in Table C4.3-1 items specified in other Sections of the specification, where they relate to work under this Section, will be listed in the Pricing Schedule.

**Table C4.3-1: Payment items from other Chapters or Sections**

Activity	Section 4.3 reference	Section item reference
Producing the material by crushing and screening	A4.3.2	Section C4.1 - All applicable items
Loading material	C4.3	C1.7.1 of Chapter 1
Hauling material (when applicable)	A4.3.7.11 and A4.3.7.12	C1.7.2 of Chapter 1
Stabilising the floor of reclaimed asphalt material stockpile site	A4.3.7.11	C5.4.2 of Chapter 5

#### (iv) Items specifically for this Section of the specifications

Item	Description	Unit
<b>C4.3.1</b>	<b>Additional material investigations</b>	
C4.3.1.1	Cost of additional core drilling and trial pits, sampling of asphalt and laboratory testing	provisional sum
C4.3.1.2	Handling cost and profit in respect of item C4.3.1.1	percentage (%)
Item	Description	Unit
<b>C4.3.2</b>	<b>Cleaning the existing road surface</b>	
C4.3.2.1	Cost to clean the road surface	provisional sum
C4.3.2.2	Handling costs and profit in respect of item C4.3.2.1	percentage (%)
Item	Description	Unit
<b>C4.3.3</b>	<b>Removal of bituminous seal surfacing (thickness not exceeding 30 mm)</b>	<b>square metre (m<sup>2</sup>)</b>

The unit of measurement shall be the square metre of seal surfacing removed separately.

The quantity shall be measured from the authorised dimensions.

The tendered rate shall include full compensation for blading or milling off the existing seal surfacing, and for loading and hauling the material to spoil sites identified by the Contractor.

All haul costs shall be included in the tendered rate of item C4.3.3.

The removal of a bituminous seal surfacing together with the underlying base layer shall not be measured in this item, but the cost shall be included with the excavation of the base layer under items C4.3.9 and C4.3.10 respectively.

Item	Description	Unit
<b>C4.3.4</b>	<b>Saw-cutting existing materials within the following average depth ranges</b>	
C4.3.4.1	Asphalt material:	
(a)	Up to 50 mm	metre (m)
(b)	Exceeding 50 mm and up to 100 mm	metre (m)
(c)	Etc, in 50 mm increments	
C4.3.4.2	Crushed stone and gravel material:	
(a)	Up to 100 mm	metre (m)
(b)	Exceeding 100 mm and up to 200 mm	metre (m)
(c)	Etc, in 100 mm increments	
C4.3.4.3	Cemented material:	
(a)	Up to 100 mm	metre (m)
(b)	Exceeding 100 mm and up to 200 mm	metre (m)
(c)	Etc, in 100 mm increments	
C4.3.4.4	Concrete material:	
(a)	Up to 50 mm	metre (m)
(b)	Exceeding 50 mm and up to 100 mm	metre (m)
(c)	Etc, in 50 mm increments	

The unit of measurement shall be the metre of saw-cut. The length in each depth range shall be measured and paid separately.

The quantities shall be measured from the authorised length of saw-cut, and the depth specified or instructed by the Engineer.

The tendered rates shall include full compensation for saw-cutting the material.

Where asphalt and the underlying layer(s) are both to be saw-cut and the asphalt is less than 50 mm thick, separate measurement and payment shall not be made for the asphalt saw-cutting in item C4.3.4.1. The asphalt thickness shall then be added to the thickness of the material in items C4.3.4.2 and/or C4.3.4.3 as applicable.

Item	Description	Unit
<b>C4.3.5</b>	<b>Providing the milling machine on the site</b>	
C4.3.5.1	Small milling machine with a cutting width of 1,2 m or smaller	number (No)
C4.3.5.2	Large milling machine with a cutting width exceeding 1,2 m	number (No)

The unit of measurement shall be the number of milling machines provided on the site, or the number of times a milling machine is brought onto the site where it had to be removed temporarily with prior approval. De-establishment and subsequent re-establishment shall also only be measured if undertaken with prior approval.

The tendered rates shall include full compensation for establishment and for de-establishment of the milling machine.

Payment for returning the machine to the site after removal shall be made only where the removal was in accordance with the Contractor's approved programme of work and not for any other reason. Payment shall not be made for replacing any defective plant.

Payment shall also not be made for moving the milling machine around on the site.

Item	Description	Unit
<b>C4.3.6</b>	<b>Milling and removal of existing asphalt layers with an average milling depth (Contractor takes ownership)</b>	
C4.3.6.1	Not exceeding 50 mm	cubic metre (m <sup>3</sup> )
C4.3.6.2	Exceeding 50 mm but not exceeding 100 mm	cubic metre (m <sup>3</sup> )
C4.3.6.3	Exceeding 100 mm	cubic metre (m <sup>3</sup> )



Item	Description	Unit
<b>C4.3.7</b>	<b>Milling and removal of existing asphalt layers with an average milling depth (Employer takes ownership)</b>	
C4.3.7.1	Not exceeding 50 mm	cubic metre (m <sup>3</sup> )
C4.3.7.2	Exceeding 50 mm but not exceeding 100 mm	cubic metre (m <sup>3</sup> )
C4.3.7.3	Exceeding 100 mm	cubic metre (m <sup>3</sup> )

The unit of measurement for items C4.3.6 and C4.3.7 shall be the cubic metre of material milled from the existing pavement.

The quantities shall be computed in accordance with the authorised dimensions of the excavation.

When instructed, split milling and removal of the different existing asphalt layers shall be measured individually.

The tendered rates for item C4.3.6 shall include full compensation for demarcating the excavation, for milling (excavating) the material, for loading and hauling to a site identified by the Contractor, and for spoil or re-use by the Contractor. All haul costs shall be included in the tendered rates of item C4.3.6.

The tendered rates for item C4.3.7 shall include full compensation for demarcating the excavation, for milling, loading, hauling and off-loading the material at a site designated by the Employer. Haul shall be measured from the point where the material is loaded to where it is off-loaded.

**Trial milling shall be measured and paid for under items C4.3.6 or C4.3.7, and no separate payment shall be made for it.**

Item	Description	Unit
<b>C4.3.8</b>	<b>Excavating material by milling</b>	
C4.3.8.1	Crushed stone material	cubic metre (m <sup>3</sup> )
C4.3.8.2	Cemented material	cubic metre (m <sup>3</sup> )
C4.3.8.3	Natural gravel material	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of milled material.

The quantities shall be measured in place on the existing road before the excavation commences.

The tendered rates shall include full compensation for milling out and loading the material.

**Trial milling shall be measured and paid for under item C4.3.8, and no separate payment shall be made for it.**

Item	Description	Unit
<b>C4.3.9</b>	<b>Excavating material by using conventional road construction equipment</b>	
C4.3.9.1	Asphalt material	cubic metre (m <sup>3</sup> )
C4.3.9.2	Crushed stone and macadam materials	cubic metre (m <sup>3</sup> )
C4.3.9.3	Cemented material	cubic metre (m <sup>3</sup> )
C4.3.9.4	Natural gravel and sand materials	cubic metre (m <sup>3</sup> )
C4.3.9.5	Coarse fill and rock fill	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of excavated material, by using conventional road building equipment.

The quantities shall be measured in place on the existing road before the excavation commenced.

The tendered rates shall include full compensation for excavating and loading the material.

**The tendered rate for cemented material shall include for ripping or pulverising the material prior to excavating.**

Item	Description	Unit
<b>C4.3.10</b>	<b>Excavating material by using labour enhanced methods of construction</b>	
C4.3.10.1	Asphalt material	cubic metre (m <sup>3</sup> )
C4.3.10.2	Crushed stone and macadam materials	cubic metre (m <sup>3</sup> )
C4.3.10.3	Cemented material	cubic metre (m <sup>3</sup> )
C4.3.10.4	Natural gravel and sand materials	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of excavated material, by using labour enhanced methods of construction.

The quantities shall be measured in place on the existing road before the excavation commenced.

The tendered rates shall include full compensation for excavating and loading the material.

Item	Description	Unit
<b>C4.3.11</b>	<b>Breaking down a stabilised layer by using conventional road construction equipment</b>	<b>cubic metre (m<sup>3</sup>)</b>

The unit of measurement shall be the cubic metre of stabilised material that is broken down, by using conventional road building equipment.

The quantities shall be measured in place on the existing road, from thickness measurements determined by drilling cores or in trial pits.

The tendered rate shall include full compensation for all equipment, labour and supervision to break the stabilised layer. No distinction shall be made between ripping the material with a grader, or pulverising the material with a recycler or rotary machine.

Measurement and payment in this item shall only be made when the existing material is used in a **side-cut to new pavement layer operation**. For excavating the existing material and then remove it to stockpile or to spoil, measurement of item C4.3.9 shall apply that includes the breaking down by ripping or pulverising.

Item	Description	Unit
<b>C4.3.12</b>	<b>Removing of existing concrete material within the following average depth ranges</b>	
C4.3.12.1	The break-up method:	
(a)	Not exceeding 150 mm	cubic metre (m <sup>3</sup> )
(b)	Exceeding 150 mm but not exceeding 250 mm	cubic metre (m <sup>3</sup> )
C4.3.12.2	The break-up method using labour enhanced methods of construction:	
(a)	Not exceeding 75 mm	cubic metre (m <sup>3</sup> )
(b)	Exceeding 75 mm but not exceeding 200 mm	cubic metre (m <sup>3</sup> )
C4.3.12.3	The lift-out method:	
(a)	Not exceeding 150 mm	cubic metre (m <sup>3</sup> )
(b)	Exceeding 150 mm but not exceeding 250 mm	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of concrete removed.

The quantity shall be measured in place on the road or in the sidewalk before the concrete is broken up or lifted.

The tendered rates shall include full compensation for drilling of cores, and for removing and loading the concrete.

Item	Description	Unit
<b>C4.3.13</b>	<b>Lifting of existing paving blocks (specify the type or size and thickness)</b>	
C4.3.13.1	Using construction equipment	square metre (m <sup>2</sup> )
C4.3.13.2	Using labour enhanced methods of construction	square metre (m <sup>2</sup> )

The unit of measurement shall be the area of paving blocks lifted.

The quantities shall be measured in place on the road or in the sidewalk before the blocks are lifted.

The tendered rates shall include full compensation for lifting the paving blocks and for removing the bedding sand.

Distinction shall be made between the construction methods used.

Item	Description	Unit
<b>C4.3.14</b>	<b>Removing of existing road edging and services structures</b>	
C4.3.14.1	Removing of existing road edging using construction equipment:	
(a)	Kerbing and edge beams:	
(i)	In situ concrete kerbing and edge beams	cubic metre (m <sup>3</sup> )
(ii)	Precast concrete kerbing (specify type or figure number)	metre (m)
(iii)	Precast concrete kerbing (specify type or figure number) and situ concrete channel (specify dimensions)	metre (m)
(b)	Kerb inlets	number (No)
(c)	Grid inlets	number (No)
(d)	Etc., for other services structures	number (No)

C4.3.14.2 Removing of existing road edging using labour enhanced methods of construction:

(a)	Kerbing and edge beams:	
(i)	In situ concrete kerbing and edge beams	cubic metre (m <sup>3</sup> )
(ii)	Precast concrete kerbing (specify type or figure number)	metre (m)
(iii)	Precast concrete kerbing (specify type or figure number) and situ concrete channel (specify dimensions)	metre (m)
(b)	Kerb inlets	number (No)
(c)	Grid inlets	number (No)
(d)	Etc., for other services structures	number (No)

The unit of measurement for items C4.3.14.1(a)(i) and C4.3.14.2(a)(i) shall be the cubic metre of concrete removed.

The unit of measurement for items C4.3.13.1(a)(ii) and (iii) and C4.3.14.2(a)(ii) and (iii) shall be the metre of precast kerbing removed. For items C4.3.14.1(a)(iii) and C4.3.14.2(a)(iii) the length of in situ concrete channel shall not be measured separately.

The unit of measurement for items C4.3.14.1(b) and (c) and C4.3.14.2(b), (c) and (d) shall be the number of inlets.

The quantities shall be measured in place on the road before the items are removed.

The tendered rates shall include full compensation for excavation, breaking down and removing the edging.

Distinction shall be made between the construction methods used.

Item	Description	Unit
<b>C4.3.15</b>	<b>Stockpiling of road layer materials</b>	
C4.3.15.1	Asphalt material	cubic metre (m <sup>3</sup> )
C4.3.15.2	Crushed stone material	cubic metre (m <sup>3</sup> )
C4.3.15.3	Cemented material	cubic metre (m <sup>3</sup> )
C4.3.15.4	Natural gravel material	cubic metre (m <sup>3</sup> )
C4.3.15.5	Concrete pavements	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material stockpiled.

The quantities shall be measured in place on the road before excavation commenced.

The tendered rates shall include full compensation for hauling the first 1,0 km of milled or excavated material to the stockpile, and for spreading and maintaining the material in the stockpile.

Haul shall be measured starting 1,0 km from the centre point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.3.16</b>	<b>Stacking paving blocks and road edging</b>	
C4.3.16.1	Paving blocks (specify type or size and thickness)	number (No)
C4.3.16.2	Precast concrete kerbing (specify type or figure number and length of sections)	number (No)
C4.3.16.3	Precast kerb inlets	number (No)
C4.3.16.4	Precast manholes	number (No)

The unit of measurement shall be the number of units that are neatly stacked at the approved stockpile site.

The quantities shall be measured in the stockpile (stack).

The tendered rates shall include full compensation for cleaning the paving blocks or road edging items, for loading and hauling to the stockpile (stacking) site or to a position as indicated by the land or property owner, for off-loading and stacking.

Any haul costs shall be included in the tendered rates of item C4.3.16.

Item	Description	Unit
<b>C4.3.17</b>	<b>Excavate non-compliant or excess pavement layer material to spoil in sites designated by the Employer, material consisting of</b>	
C4.3.17.1	Asphalt material	cubic metre (m <sup>3</sup> )
C4.3.17.2	Crushed stone, macadam, gravel and sand material	cubic metre (m <sup>3</sup> )
C4.3.17.3	Cemented material	cubic metre (m <sup>3</sup> )
C4.3.17.4	Concrete material	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material spoiled.

The quantity shall be measured in place on the road before excavation commenced. Where this method of quantification is not feasible or where the quality of material is only identified after it has been excavated, the Engineer may approve that the quantity be taken as equal to 70 % of the loose volume of the material in the haul vehicles be used to transport asphalt, crushed stone, macadam, gravel, sand and cemented materials, and in the case of concrete materials to 50 % of the loose volume of material in the haul vehicles.

The tendered rates shall include full compensation for breaking down the material, excavating, and for disposing the material, including shaping and levelling-off any heaps of spoil material.

Haul shall be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.3.18</b>	<b>Excavate non-compliant or excess pavement layer material to spoil in sites designated by the Contractor, material consisting of</b>	
C4.3.18.1	Asphalt material	cubic metre (m <sup>3</sup> )
C4.3.18.2	Crushed stone, macadam, gravel and sand material	cubic metre (m <sup>3</sup> )
C4.3.18.3	Cemented material	cubic metre (m <sup>3</sup> )
C4.3.18.4	Concrete material	cubic metre (m <sup>3</sup> )

The unit of measurement shall be the cubic metre of material spoiled.

The quantity shall be measured in place on the road before excavation commenced. Where this method of quantification is not feasible or where the quality of material is only identified after it has been excavated, the Engineer may approve that the quantity be taken as equal to 70 % of the loose volume of the material in the haul vehicles.

The tendered rates shall include full compensation for negotiations with the land owner or legal occupant of the property or of the spoil site, for breaking down the various materials, excavating, loading and hauling the material to the spoil sites irrespective of the haul distance, for off-loading and disposing the material, and for finishing the spoil site and obtaining the approval of the property or spoil site owner, if applicable.

The tendered rate shall also include the cost of spoiling at a municipal site, if applicable.

All haul costs shall be included in the tendered rates of item C4.3.18.

Item	Description	Unit
<b>C4.3.19</b>	<b>Spoiling of paving blocks and road edging in spoil sites designated by the Employer</b>	
C4.3.19.1	Paving blocks	cubic meter (m <sup>3</sup> )
C4.3.19.2	Precast and in situ concrete kerbing, edge beams and channels at precast kerbing	cubic metre (m <sup>3</sup> )
C4.3.19.3	Kerb and grid inlets, and other services structures	number (No)

The unit of measurement shall be the cubic metre of material spoiled.

The quantities shall be taken as equal to 70 % of the loose volume in the haul vehicles.

The tendered rates shall include full compensation for loading the materials, and for disposing the materials. The tendered rates shall also include the cost of spoiling at a municipal site, if applicable.

Haul shall be measured from the point where the material is loaded to where it is off-loaded.

Item	Description	Unit
<b>C4.3.20</b>	<b>Spoiling of paving blocks and road edging in spoil sites designated by the Contractor</b>	
C4.3.20.1	Paving blocks	cubic meter (m <sup>3</sup> )
C4.3.20.2	Precast and in situ concrete kerbing, edge beams and channels at precast kerbing	cubic metre (m <sup>3</sup> )
C4.3.20.3	Kerb and grid inlets, and other services structures	number (No)

The unit of measurement shall be the cubic metre of material spoiled.

The quantities shall be taken as equal to 70 % of the loose volume in the haul vehicles. The tendered rates shall include full compensation for loading the materials, for hauling to the spoil site irrespective of the haul distance, and for off-loading and disposing the materials.

The tendered rates shall also include the cost of spoiling at a municipal site, if applicable.

All haul costs shall be included in the tendered rates of item C4.3.20.

# QUESTIONS?

# BREAK!

### 1.7.1 Section 4.4: Commercial Materials Materials and requirements



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### Content of this Section

- Commercial materials
- Stabilisation since the stabilisation agents are also commercially obtained materials



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## Commercial materials definition

- Commercial materials = gravel, sand and crushed stone sourced from:
  - Commercial suppliers
  - Private or other non-commercial suppliers
  - From the Employer's or Contractor's own sources



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## Stabilisation definition

- Treatment of material to:
  1. Enhance the **strength and stiffness**
  2. Make the material more water **resistant**
- Result: **Durability** is improved



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## Stabilisation issues

- Theory of modification and cementation not understood
- Reactions of different stabilisers not understood
- Responsibility for design not addressed
- Incomplete testing – ICS and WDD, and working time
- Incorrect testing – no 7-day curing
- No phenolphthalein testing during construction
- Cement in design and construction differs



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## Types of stabilisation

- Mechanical modification (granular)
- Chemical (cementitious agents)
- Electrical (ion exchange)
- Material improvement (BSM)
- Geosynthetic (new TG3 still to be published)



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## Traditional stabilising agents

- **Cementitious** agents:
  - Cement
  - Lime (hydrated)
- **Bituminous** agents
  - Emulsions
  - Penetration grade bitumen (foamed bitumen)



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## Cement types

Main types	Notation of products (types of common cement)		Composition, percentage by mass <sup>(a)</sup>										Minor additional constituents
			Clinker	Blast-furnace slag	Silica fume	Pozzolana Natural	Pozzolana calcined	Fly ash Siliceous	Fly ash Calcareous	Burnt shale	Limestone		
			K	S	D <sup>(b)</sup>	P	Q	V	W	T	L	LL	
CEM I	Portland cement	CEM I	95 - 100	-	-	-	-	-	-	-	-	-	0 - 5
	Portland-slag cement	CEM II A-S	80 - 94	6 - 20	-	-	-	-	-	-	-	-	0 - 5
		CEM II B-S	65 - 79	21 - 35	-	-	-	-	-	-	-	-	0 - 5
	Portland-silica fume cement	CEM II A-D	90 - 94	-	6 - 10	-	-	-	-	-	-	-	0 - 5
	Portland-pozzolana cement	CEM II A-P	80 - 94	-	-	6 - 20	-	-	-	-	-	-	0 - 5
		CEM II B-P	65 - 79	-	-	21 - 35	-	-	-	-	-	-	0 - 5
		CEM II A-Q	80 - 94	-	-	-	6 - 20	-	-	-	-	-	0 - 5
		CEM II B-Q	65 - 79	-	-	-	21 - 35	-	-	-	-	-	0 - 5
	Portland-fly ash cement	CEM II A-V	80 - 94	-	-	-	-	6 - 20	-	-	-	-	0 - 5
		CEM II B-V	65 - 79	-	-	-	-	21 - 35	-	-	-	-	0 - 5
CEM II		CEM II A-W	80 - 94	-	-	-	-	6 - 20	-	-	-	0 - 5	
		CEM II B-W	65 - 79	-	-	-	-	21 - 35	-	-	-	0 - 5	
CEM II	Portland-burnt shale cement	CEM II A-T	80 - 94	-	-	-	-	-	6 - 20	-	-	0 - 5	
		CEM II B-T	65 - 79	-	-	-	-	-	21 - 35	-	-	0 - 5	
	Portland-limestone cement	CEM II A-L	80 - 94	-	-	-	-	-	-	6 - 20	-	0 - 5	
		CEM II B-L	65 - 79	-	-	-	-	-	-	21 - 35	-	0 - 5	
		CEM II A-LL	80 - 94	-	-	-	-	-	-	-	6 - 20	0 - 5	
		CEM II B-LL	65 - 79	-	-	-	-	-	-	-	21 - 35	0 - 5	
	Portland-composite cement <sup>(c)</sup>	CEM II A-M	80 - 94	←	←	←	←	6 - 20	←	←	←	0 - 5	
		CEM II B-M	65 - 79	←	←	←	←	21 - 35	←	←	←	0 - 5	
	CEM III	Blastfurnace cement	CEM III A	35 - 64	36 - 65	-	-	-	-	-	-	-	0 - 5
			CEM III B	20 - 34	66 - 80	-	-	-	-	-	-	-	0 - 5
CEM III C			5 - 19	81 - 95	-	-	-	-	-	-	-	0 - 5	
CEM IV	Pozzolanic cement <sup>(c)</sup>	CEM IV A	65 - 89	←	←	←	11 - 35	←	←	←	0 - 5		
		CEM IV B	45 - 64	←	←	←	36 - 55	←	←	←	0 - 5		
CEM V	Composite cement <sup>(c)</sup>	CEM V A	40 - 64	18 - 30	←	←	←	18 - 30	←	←	←	0 - 5	
		CEM V B	20 - 39	31 - 50	←	←	←	31 - 50	←	←	←	0 - 5	



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## Cement types not to be used

1. Strength class 42.5 and 52.5 cements (too high)
  2. CEM I (rapid setting)
  3. CEM III B, III C and V/B (low clinker content)
  4. High strength "R" cement, except when early trafficking
  5. Masonry cement
- Proprietary cement blends?



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## Non-traditional agents

- Sulphonated petroleum products (SPPs)
- Polymers
- Nano-technology products



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## Use of non-traditional agents

- Not prohibited
- **Engineer** can specify and give details of product, method and rate of application, construction method statement, curing, measurement and payment items
- **Contractor** can propose and provide information listed in A4.4.5.4
- **Important** – requirements apply as for chemically stabilised materials in Table A4.4.5-2 but standard tests may have to be modified



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## Dust pallitives

- Subject to a performance base system
- Details in Part D:
  - Information to be provided by Employer
  - Information to be submitted by the Contractor



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## Chemical stabilisation requirements

Classification		C2	C3	C4
Type of material before stabilisation		At least G4A quality	At least G5B quality	At least G6 quality
Maximum particle size		50 mm	Base 50 mm, Subbase 63 mm	
PI after stabilisation		Non-plastic	Basic crystalline material: NP	
			Other materials: 6	
UCS (Unconfined Compression Strength) (MPa) at 100 % of MDD <sup>(1)</sup>	Min	3,0	1,5	0,75
	Max	5,0	3,0	
ITS (Indirect Tensile Strength) (kPa) at 100 % of MDD	Min	300	250	200
	Max	600	500 <sup>(2)</sup>	450 <sup>(2)</sup> (350) <sup>(3)</sup>
WDD (Wet/Dry Durability) (mass loss maximum)		10 %	20 %	30 %



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## Notes on stabilised material requirements

1. COLTO C1 dropped
2. UCS now only at 100 % MDD
3. UCS and ITS at 7-day curing and not rapid (24-hr) curing
4. Rapid curing can still be used for construction assessment, with calibration against the 7-day result
5. ITS the more important property to be met than the UCS
6. Max UCS and ITS not relevant in block pavement subbase
7. Max UCS and ITS in a subbase can be exceeded without risk under a good constructed G1 base



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## BSM requirements

Table A4.4.5-3: Requirements for BSMs

Test		Specimen size, compaction effort and curing	BSM Classification	
			BSM1	BSM2
Type of material before stabilisation			At least G4B quality	At least G5B quality
Grading, $P_{0.075}$ , PI and DMI for BSM-emulsion and BSM-foam			Refer TG2 clause 4.7 and 4.8	
ITS <sub>dry</sub> (Indirect Tensile Strength) (kPa)		152 mm dia x 95 mm high vibratory hammer or MDD compaction cured to constant mass	> 225	> 175
ITS <sub>wet</sub> (Indirect Tensile Strength) (kPa)			> 125	> 100
Shear parameters	Friction angle (°)	150 mm dia x 300 mm high vibratory hammer compaction cured at equilibrium moisture content	> 40 (38)	> 38 (35)
	Cohesion (kPa)		> 250 (265)	> 200 (225)
	Retained cohesion (%)		> 75 (75)	> 65 (75)



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## Notes on BSM material requirements

1. COTO aligned with Sabita Technical Guideline TG2 August 2020
2. BSM3 dropped
3. Grading,  $P_{0.075}$  and PI changed from G-type classification
4. BSM tests included in TG2 Appendix B



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QUESTIONS?



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### **1.7.2. Section 4.4 – Commercial Materials Mix designs, Measurement and payment**

#### A4.4.7.1 Selection (design) of the stabilising agent content

##### a) Purpose of the selection process

The purpose of selecting the stabilisation content is to find the optimum combination of gravel or crushed material and stabilising agent that will provide the required strength and durability to ensure adequate structural capacity of the layer but not excessive for the design life of the road. This requires that the correct type and quantity of stabilising agent are determined.

##### b) Sampling of materials

For determining the positions of sampling and trial pits and during the taking of samples, it shall always be remembered that material properties can vary. Crushed aggregate, and more so gravels which are partly weathered, have properties that can vary considerably as a result of the effect of chemical reactions (hydration, hydrolysis and so forth), physical processes (leaching, saturation and so forth) and the effect of the environment (depth, water flows, temperatures and so forth). Adequate sampling shall always be carried out to ensure that representative test results are obtained. Samples shall also be taken from the point of availability of the material earmarked for stabilisation (generally in stockpile).

##### c) Cementitious stabilising agent for chemical stabilisation

The Engineer, in consultation with the Contractor, will carry out the process to select the cementitious stabilising agent in an agreed laboratory.

The Contractor shall provide the laboratory with an adequate quantity of the natural material and stabilising agent for the laboratory to use in the testing procedures. The stabilisation design testing may take up to 8 weeks to conclude. The Contractor shall identify the material for stabilisation timeously to prevent delays to the contract.

The cementitious stabilising agent selection process for stabilisation shall be undertaken in a four-step sequence.

##### Step 1: Determine the compliance of the natural material.

The natural or untreated material shall be tested for compliance. Refer Table A4.4.5-2 in this Section and Tables A4.1.5-3, A4.1.5-4 and A4.1.5-5 in Section A4.1. The material may have to be processed by crushing, screening or crushing and screening, blended with other materials or pre-treated with lime or another stabilising agent if required, to meet the specifications of the material before stabilisation testing commences.

The material shall also be tested for deleterious minerals, especially for sulfates, for compliance with the requirements in Section 4.1 Clause A4.1.5.17.

Sugar has also deleterious effects on cement that may affect stabilisation in sugarcane farming areas. The presence of sugar in material in these areas must be tested in accordance with SANS 5833.

##### Step 2: Determine the Initial Consumption of Stabiliser (ICS) of the material.

The pH shall be tested of samples prepared at varying stabiliser contents. The stabiliser content in percentage at which the pH reading does not increase by more than 0,1 % compared to the next reading, shall be taken as the ICS of the material.

##### Step 3: Determine the compliance of the stabilised material.

Samples of the material and stabilising agent shall then be prepared at stabiliser contents of 1,0 %, 1,5 %, 2,0 % and 2,5 % more than the ICS percentage identified in Step 2. The PI, UCS and ITS of all samples shall be tested at 7-day curing and evaluated against the requirements in Table A4.4.5-2. Samples cured at 24-hour rapid curing shall also be prepared and tested the same time for comparison with the 7-day curing results, should the results of the rapid curing be used for the construction quality control.

If it is not possible to fully comply with both the UCS and ITS specified requirements, then compliance with the ITS requirement takes precedence.

The selected stabilising agent and content, increased to represent the construction method, will then be chosen that meet the requirements for PI and ITS in Table A4.4.5-2.

When required by the Engineer, the addition of more stabilising agent to allow for variations in material properties and stabiliser distribution shall be assessed during the construction of the trial section specified in Chapter 5.

##### Step 4: Determine the durability of the stabilised material, the effect of the test curing period on the ITS, and the field working time.

The Engineer shall indicate the stabiliser content(s) for the tests below, but it shall generally be carried out at the content chosen in Step 3 and at a stabiliser content of 0,5 % higher.

###### (i) Durability of the stabilised briquettes

For durability the wet/dry brushing test shall be done. Should the wet/dry durability (WDD) requirement in Table A4.4.5-2 be met, the Engineer shall then confirm the stabilising agent and the application rate. Should the wet/dry durability requirement not be met, the test shall be repeated with higher contents of stabilising agent until the durability specification is met, or other types of stabilising agent shall be considered and the design steps repeated.

Stabilisation on the road may be permitted by the Engineer before the results of the wet/dry durability test are available, but only where historical results of the durability tests on material from the same source have complied with the specification.

###### (ii) ITS correlation between 7-day and 24 hr curing times

Parallel testing shall be carried out to establish for quality assurance testing the correlation between the ITS values at 7-day curing at the temperature of the standard test, and of the rapid curing test of 24 hours at elevated temperature, on material with the same stabiliser content.

###### (iii) Field working time

This test procedure for the field working time gives an indication of the maximum time for completion of the stabilised layer after commencement of the addition of the stabilising agent to the material. The working time shall be assessed by testing the ITS at rapid curing at increasing standing periods after the stabilising agent is mixed with the material. The field working time limit is then where the specified ITS requirement can still be achieved. The specified working time for construction stabilisation shall not exceed the construction time limitations specified in Section 5.4 of Chapter 5.



#### **d) Bituminous stabilising agent for material improvement**

The Engineer, in consultation with the Contractor, will carry out the process to select the bituminous stabilising agent in an agreed to laboratory.

The requirements for the various test results hereunder are specified in Table A4.4.5-3. The Contractor shall provide the laboratory with a sufficient quantity of the bituminous stabilising agent and active fillers for use in the various testing procedures.

The stabilising agent selection process of BSMS shall be undertaken in a three-step sequence as below. (Note: a more extensive explanation and description is given in the Sabita Guideline TG2).

##### **Step 1: Determine the compliance of the natural material.**

The selection process starts by testing whether the natural material to be treated is compliant for treating with bitumen and, if not, to ascertain the producing of the material by crushing, screening or crushing and screening, and if pre-treatment is required, with a cementitious stabilising agent or blending with other materials to make it compliant. For the material requirements refer Table A4.4.5-3 in this Section and Tables A4.1.5-4 and A4.1.5-5 in Section A4.1.

##### **Step 2: Determine the effect of active filler and the optimal binder content.**

ITS tests are carried out to determine the effect of adding an active filler in conjunction with the bituminous stabilising agent. Three samples are normally tested, all with the same application of bituminous stabilising agent. Following the relevant test procedure, no active filler is added to the first sample, 1 % (by mass) cement is added to the second sample and 1 % (by mass) hydrated lime is added to the third sample. (Additional samples may be treated with other active fillers or a greater mass of filler if required.) Six ITS specimens are manufactured from each of the three (or more) treated samples. After curing, half the ITS specimens are soaked in water for 24 hours before testing to determine the ITS<sub>WET</sub> values. The ITS<sub>DRY</sub> values are obtained from the unsoaked ITS specimens.

The active filler in the mix that achieves the highest ITS<sub>WET</sub> value is selected as the preferred active filler and is applied to the mixes used to manufacture specimens for all further tests.

(Note. When there is a significant increase in the ITS<sub>DRY</sub> value of specimens treated with and without active filler, the ITS test procedure is repeated with a reduced application rate of 0,75 % active filler.)

Similar to the procedure to select the optimal filler content, ITS tests are carried out to determine the effect of adding different amounts of bituminous stabilising agent to samples all treated with the same amount of active filler. The ITS<sub>DRY</sub> and ITS<sub>WET</sub> values achieved are plotted against the respective amounts of stabilising agent on a graph, and the amount of agent that yields the ITS values specified for the required BSM classification is selected as the optimum.

##### **Step 3: Evaluate the shear properties.**

A large sample is prepared by adding active filler and bituminous stabilising agent at the application rates determined in Steps 1 and 2. Ten 150 mm diameter x 300 mm high specimens are manufactured and cured. Monotonic triaxial tests are then carried out on eight of the specimens (2 each at 4 different confining pressures) to determine the shear properties (the internal friction angle and cohesion) as well as the retained cohesion (determined from tests on the remaining two samples after soaking in water for 24 hours).

#### **A4.4.7.2 Storage of stabilising agents on site**

##### **a) Cement provided in pockets**

Cement delivered in pockets can be kept at the road on pallets or on a raised platform for no longer than two weeks. The pockets shall always be protected from the ingress of any moisture with a waterproof tarpaulin or plastic cover not less than 1,0 mm thick.

For longer storage periods, the cement bags shall be stored in a shed. The requirements for the shed and for storing are:

- Storage sheds shall be watertight and of solid construction.
- The floor shall be waterproof and covered with plastic sheets not less than 1,0 mm thick.
- The pockets shall be stored on the delivery pallets, which must be stacked closely together (to reduce the circulation of air) and away from any outside walls.
- Pockets shall be stored in such a way that older pockets are used first.
- Vertical stacking of loose pockets shall not exceed 12 pockets high.
- Doors and windows shall be kept shut.

The permitted shelf life of cement stored in a shed is 6 months inland and 3 months in coastal areas. Cement which has been properly stored in an approved shed as specified above for longer than these periods, or at the road side for more than two weeks, shall not be used in the stabilisation works.



#### b) Lime

Lime can be kept at the road for **up to six months** on pallets or on a raised platform. The pockets shall always be protected from the ingress of any moisture with a waterproof tarpaulin or a plastic cover not less than 1,0 mm thick.

#### c) Bitumen

The maximum storage temperatures for penetration grade bitumens are given in Table A9.1.7.1 of Chapter 9. Binders stored in a heated condition shall be kept in a container with a securely fitting lid and the circulatory system that is functioning properly. The container shall be provided with a build-in thermometer. Binders which have been heated above the maximum allowed temperatures shall not be used and shall be removed from the site.

Bitumen emulsion shall be stored at ambient temperature in storage tanks fitted with a circulating pump system, which will enable the stored bitumen emulsion to be properly circulated in the static tank, especially when no bitumen emulsion has been drawn or added for a period of 2 to 3 consecutive days. The supplier shall be contacted for the maximum storage period.

#### d) Placing on the road

Pockets of stabilising agents shall only be placed immediately before the mixing and compaction operations are carried out, and after the gridlines have been marked out on the surface to ensure the correct application rate. Where this is not practical and approved by the Engineer, then pockets shall not be left on the road for longer than one day after placing the pockets prior to spreading the agent, as it may absorb moisture from the underlying layer or be damaged during other construction activities.

When the pockets of stabilising agents are placed on the road during periods of wet weather and get wet before the agent is spread and mixed into the layer, then the agent shall be removed to spoil and replaced with new dry agent at no cost to the Employer.

Where a pocket is broken on the road and mixing and compaction are not done within the specified time, the agent in the broken pocket shall be removed to spoil and replaced with new dry agent at no cost to the Employer.

When the stabilising agent is delivered to site in bulk tankers then the agent may only be dispensed onto the road immediately before the mixing and compaction operations are carried out.

### A4.4.8 WORKMANSHIP

The Engineer and the Contractor shall determine and agree on the testing protocol and frequency of the applicable process control tests required for the commercial materials, to ensure that the quality of the materials meets the specified requirements for the particular layer for which it will be used.

The stabilised material and designs shall always be tested and evaluated by constructing and testing of a trial section. After the type and quantity of stabiliser have been finalised, the Contractor shall further take full responsibility for compliance of the constructed stabilised layer with the requirements.

Measurement, testing, and evaluation of all individual components and constructed products shall be in accordance with the methods prescribed in this Section or in Chapter 20 as relevant.

## C4.4 COMMERCIAL MATERIALS

### 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 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. **(Additional note: Payment of only 80 % for materials on site not applicable to this Section.)**

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

Loading of the commercial materials at the source, hauling it to the road, and off-loading will not be measured and paid for separately.

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

For commercial materials from private or non-commercial suppliers identified by the Employer and that must still be excavated, produced and/or stockpiled, the Employer may decide to have a cost breakdown of the individual activities such as excavation, crushing and so forth. The pricing of item C4.4.1 will then not be applicable, and measurement and payment shall be made in accordance with the applicable items in Section C4.1.

#### (iv) Items specifically for this Section of the specifications

Item	Description	Unit
<b>C4.4.1</b>	<b>Commercial materials identified by the Employer from commercial, private or other non-commercial suppliers (specify the source(s))</b>	
C4.4.1.1	Pavement layer material:	
(a)	Type G1 material	cubic metre (m <sup>3</sup> )
(b)	Type G2 material	cubic metre (m <sup>3</sup> )
(c) – (l)	Etc, for other Type G3 to G9 materials	cubic metre (m <sup>3</sup> )
(m)	Sand for the base and shoulder layers	cubic metre (m <sup>3</sup> )
(n)	Sand for a subbase layer	cubic metre (m <sup>3</sup> )
(o)	Sand for a selected layer	cubic metre (m <sup>3</sup> )
(p)	Natural or crushed gravel material for an unsealed shoulder layer	cubic metre (m <sup>3</sup> )
(q)	Natural or crushed gravel material for the wearing course of an unsealed road	cubic metre (m <sup>3</sup> )
C4.4.1.2	Macadam material:	
(a)	Coarse aggregate	cubic metre (m <sup>3</sup> )
(b)	Fine aggregate	cubic metre (m <sup>3</sup> )
C4.4.1.3	Drainage blanket layer material	cubic metre (m <sup>3</sup> )
C4.4.1.4	Soil cement material (pre-blended by the supplier)	cubic metre (m <sup>3</sup> )
C4.4.1.5	Fill material in the earthworks:	
(a)	Normal or coarse fill	cubic metre (m <sup>3</sup> )
(b)	Rock fill	cubic metre (m <sup>3</sup> )
(c)	Sand	cubic metre (m <sup>3</sup> )
C4.4.1.6	Pioneer material	cubic metre (m <sup>3</sup> )

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

The quantities for items C4.4.1.1 to C4.4.1.4 shall be measured in place in the compacted pavement layers and calculated from the authorised dimensions of the layers.

The quantities for item C4.4.1.5 shall be measured in place, from the difference between levelled cross sections at 20 m maximum intervals taken before and after the construction. The quantities shall not include excess material, overfill material or additional material placed for bulking (settlement during compaction).

The quantity for item C4.4.1.6 shall be taken as equal to 50 % of the loose volume of the material in the haul vehicles.

The tendered rates shall include full compensation for negotiations to procure and furnish the commercial materials, for loading the material at the source, hauling it to the road, and for off-loading. Temporary stockpiling of the material after procurement by the Contractor shall not be paid for.

The tendered rates for commercial materials from commercial suppliers shall also include full compensation for procuring the material. Additional crushing, screening and stockpiling of commercial material acquired from commercial suppliers shall not be measured and paid for separately.

For commercial materials from private or non-commercial suppliers, separate measurement and payment shall be made for breaking down oversize material, crushing, screening, and stockpiling as may be required and when specified in the Contract Documentation, or agreed to with prior written approval by the Engineer. Measurement and payment shall then be made according to the applicable items in Section C4.1. Procurement of the commercial material from the private or non-commercial suppliers by the Contractor, if specified in the Contract Documentation, shall be measured and paid for separately under item C4.4.3.

The materials from different sources shall be measured and paid separately.

All haul costs shall be included in the tendered rates of item C4.4.1.

Item	Description	Unit
<b>C4.4.2</b>	<b>Commercial materials identified by the Contractor from commercial, private or other non-commercial suppliers</b>	
C4.4.2.1	Pavement layer material:	
(a)	Type G1 material	cubic metre (m <sup>3</sup> )
(b)	Type G2 material	cubic metre (m <sup>3</sup> )
(c) – (l)	Etc, for other Type G3 to G9 materials	cubic metre (m <sup>3</sup> )
(m)	Sand for the base and shoulder layers	cubic metre (m <sup>3</sup> )
(n)	Sand for a subbase layer	cubic metre (m <sup>3</sup> )
(o)	Sand for a selected layer	cubic metre (m <sup>3</sup> )
(p)	Natural or crushed gravel material for an unsealed shoulder layer	cubic metre (m <sup>3</sup> )
(q)	Natural or crushed gravel material for the wearing course of an unsealed road	cubic metre (m <sup>3</sup> )
C4.4.2.2	Macadam material:	
(a)	Coarse aggregate	cubic metre (m <sup>3</sup> )
(b)	Fine aggregate	cubic metre (m <sup>3</sup> )
C4.4.2.3	Drainage blanket layer material	cubic metre (m <sup>3</sup> )
C4.4.2.4	Soil cement material (pre-blended by the supplier)	cubic metre (m <sup>3</sup> )
C4.4.2.5	Fill material in the earthworks:	
(a)	Normal or coarse fill	cubic metre (m <sup>3</sup> )
(b)	Rock fill	cubic metre (m <sup>3</sup> )
(c)	Sand	cubic metre (m <sup>3</sup> )
C4.4.2.6	Pioneer material	cubic metre (m <sup>3</sup> )

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

The quantities for items C4.4.2.1 to C4.4.2.4 shall be measured in place in the compacted pavement layers and calculated from the authorised dimensions of the layers.

The quantities for item C4.4.2.5 shall be measured in place, from the difference between levelled cross sections at 20 m maximum intervals taken before and after the construction. The quantities shall not include excess material, overfill material or additional material placed for bulking (settlement during compaction).

The quantity for item C4.4.2.6 shall be taken as equal to 50 % of the loose volume of the material in the haul vehicles.

The tendered rates shall include full compensation for negotiations, taking of samples and laboratory testing of the natural material to prove compliance with the specified properties, procuring and furnishing the commercial materials, for loading the material at the source, hauling it to the road, and for off-loading. Temporary stockpiling of the material after procurement by the Contractor shall not be paid for.

When the commercial materials are identified and proposed by the Contractor as an alternative material source to those identified by the Employer, the tendered rates shall also include full compensation for taking of samples of the material, for laboratory testing of the natural material, and for the stabilisation design and providing and applying stabilising agents should they be necessary to improve the properties of the natural material to be compliant with the specifications.

No distinction shall be made for materials acquired from different sources.

All haul costs shall be included in the tendered rates of item C4.4.2.

Item	Description	Unit
<b>C4.4.3</b>	<b>Cost to procure commercial materials identified by the Employer from private or non-commercial sources</b>	
C4.4.3.1	Cost of procuring	provisional sum
C4.4.3.2	Handling cost and profit in respect of item C4.4.3.1	percentage (%)

Item	Description	Unit
<b>C4.4.4</b>	<b>Cementitious stabilising agents</b>	
C4.4.4.1	Cement	ton (t)
C4.4.4.2	Road lime	ton (t)
C4.4.4.3	Etc, for other agents	ton (t)

The unit of measurement shall be the ton of stabilising agent.

The quantity of stabilising agent shall be determined in accordance with the authorised application rate. No over application or wastage shall be measured for payment.

The tendered rates shall include full compensation for procuring, transporting and delivering the stabilising agent to the site. No distinction shall be made between providing the stabilising agent in bulk or in pockets.

For providing the stabilising agent in pockets, the tendered rates shall also include full compensation for off-loading the pockets, for short term and/or long term storage.

All haul costs shall be included in the tendered rates of item C4.4.4.

Placing, spreading and mixing in the stabilising agent(s) on the road shall be measured and paid for under the applicable items in Chapter 5.

Item	Description	Unit
<b>C4.4.5</b>	<b>Bituminous stabilising agents</b>	
C4.4.5.1	Penetration grade bitumen (specify grade)	ton (t)
C4.4.5.2	Emulsion stable grade (specify type)	ton (t)

The unit of measurement shall be the ton of bituminous stabilising agent. (Additional note: COLTO measured it in litre.)

The method of calculating the quantity shall be specified in the Contract Documentation or as agreed between the Engineer and the Contractor, and shall be one of the following methods:

- Determined in accordance with the authorised application rate.
- Based on dipstick readings where the dipstick has been calibrated to the tanker, and the quantity measured at the applicable temperature.
- Based on assized weighbridge tickets issued for each and every tanker-load of stabilising agent consumed in the stabilisation process. The quantity thus measured shall not exceed the quantity calculated using the authorised application rate by more than 4 %.

The quantity shall include for a double treatment of stabilising agent over a nominal 150 mm overlap width along longitudinal joints.

The tendered rates shall include full compensation for procuring, transporting and delivering the bituminous stabilising agent to the site, for transfer into storage tanks, storage and heating, for issuing the required assized weighbridge ticket showing the mass of the contents in the tanker if applicable, for any re-heating required, for all wastage and for strict adherence to all safety measures required when handling warm bitumen emulsion or hot bitumen. No distinction shall be made for supplying the stabilising agent in bulk or in drums.

All haul costs shall be included in the tendered rates of item C4.4.5.

Using and applying the bituminous stabilising agent in the road layers shall be measured and paid for under the applicable items in Chapter 5.

Item	Description	Unit
<b>C4.4.6</b>	<b>Fillers for bituminous stabilisation (specify filler types separately)</b>	<b>ton (t)</b>

The unit of measurement shall be the ton of filler.

The quantity of filler shall be determined in accordance with the authorised application rate.

The tendered rate shall include full compensation for procuring and transporting the filler to the site, for off-loading and storing the filler.

Application of the filler and spreading on the road shall be measured and paid for under the applicable items in Chapter 5.

Item	Description	Unit
<b>C4.4.7</b>	<b>Sampling and material testing by a commercial laboratory for the stabilisation designs</b>	
C4.4.7.1	Cost of sampling and material testing	provisional sum
C4.4.7.2	Handling cost and profit in respect of item C4.4.7.1	percentage (%)

## D4.4 COMMERCIAL MATERIALS

### PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

#### CONTENTS

- D4.4.1 SCOPE
- D4.4.2 GENERAL
- D4.4.3 PERFORMANCE GUARANTEE REQUIREMENTS
- D4.4.4 FUNCTIONAL PERFORMANCE ASSESSMENTS
- D4.4.5 VISUALLY ASSESSED PROPERTIES
- D4.4.6 INSTRUMENTALLY ASSESSED PROPERTIES
- D4.4.7 EVALUATION FOR ACCEPTANCE
- D4.4.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE
- D4.4.9 NOTIFICATION OF REMEDIAL WORK
- D4.4.10 REMEDIAL WORKS

#### D4.4.1 SCOPE

Dust palliatives shall be subject to the provision of a performance guarantee by the manufacturer and/or supplier of the dust palliative.

#### D4.4.2 GENERAL

The Employer shall identify the location and extent of the unsealed road for which a dust palliative is required.

#### D4.4.3 PERFORMANCE GUARANTEE REQUIREMENTS

##### D4.4.3.1 Information to be provided by the Employer

The Employer will provide the following basic information of the gravel wearing course material and requirements of the guarantee:

- Properties of the wearing course material,
- Expected volume and type of traffic on the road,
- Performance and other requirements for the palliative, whether for dust control, strengthening or both,
- Duration and format of the guarantee,
- Payment conditions of the guarantee, and
- Assessments and testing criteria for the treated material during the guarantee period.

##### D4.4.3.2 Information to be submitted by the Contractor

The Contractor shall submit the following information about the dust palliative:

- The type of dust palliative, whether it be one of the following types:
  - A surfactant that is added to water in order to improve its ability to wet and penetrate the gravel wearing course,
  - A non-bond forming palliative that is applied directly onto the wearing course surface and where there is no gluing of the surface, or
  - A bond forming or gluing palliative that bonds the dust particles and that is applied by mixing the palliative into the wearing course.
- The basis material of the palliative,
- Further application intervals during the guarantee period,
- Restriction on the use such as near watercourses or other environmentally sensitive areas,
- Construction and application methods,
- Construction equipment required to apply the palliative,
- Curing time and restrictions for opening the road,
- An inspection management system of the inspection frequency, items to be inspected and rating,
- A payment schedule of costs comprising the initial application and of further applications during the guarantee period,

- Expected condition of the wearing course at the assessment times and at the end of the guarantee period, and
- Project details of previous use of the dust palliative with project references and contact details.

#### **D4.4.4 FUNCTIONAL PERFORMANCE ASSESSMENTS**

Details must be provided in the Contract Documentation.

#### **D4.4.5 VISUALLY ASSESSED PROPERTIES**

Details must be provided in the Contract Documentation.

#### **D4.4.6 INSTRUMENTALLY ASSESSED PROPERTIES**

Details must be provided in the Contract Documentation when applicable.

#### **D4.4.7 EVALUATION FOR ACCEPTANCE**

Details must be provided in the Contract Documentation.

#### **D4.4.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE**

Details must be provided in the Contract Documentation.

#### **D4.4.9 NOTIFICATION OF REMEDIAL WORK**

Details must be provided in the Contract Documentation.

#### **D4.4.10 REMEDIAL WORKS**

Details must be provided in the Contract Documentation.

QUESTIONS?

BREAK!



## **1.8. Section 4.5 – Alternative Materials**

## 4.5 ALTERNATIVE MATERIALS

### CONTENTS

#### PART A: SPECIFICATIONS

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- A4.5.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS
- A4.5.5 MATERIALS
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#### PART B: LABOUR ENHANCEMENT

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#### PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

## A4.5 ALTERNATIVE MATERIALS

### PART A: SPECIFICATIONS

#### A4.5.1 SCOPE

This section covers the work requirements for sourcing alternative materials that can be used for the construction of road earthworks and road pavement layers, and which are obtained from sources other than from borrow pits and quarries, or from cuttings, box cuts and designated excavations, or from the existing road or from commercial sources.

Chapter 5 – Earthworks and Pavement layers: Construction, covers the construction of the road layers.

#### A4.5.2 DEFINITIONS

The relevant definitions in Chapter 1 and Clause A4.1.2 shall also be applicable for this Section. Additional definitions for this Section are listed below.

**Alternative materials** - include all recovered materials considered compliant for the construction of earthworks and pavement layers, with or without additional processing, that are obtained from operations not necessarily related to road construction. Such operations include, but are not limited to:

- Construction and demolition of structures.
- Industrial operations.
- Mining operations.

Geosynthetic materials built into the earthworks and road pavement layers are not defined as alternative materials.

**Construction and demolition material** - is produced in the process of construction, renovation, or demolition of structures. Structures include buildings of all types (both residential and non-residential), as well as roads and bridges.

Components of construction and demolition material typically include concrete, bricks, mortar, asphalt, metals, floor tiles, roofing and ceiling materials, dry walls, window materials, pipes, floor materials and other components. It may also contain some wood fragments, soil and rock fragments. Construction and demolition material is also referred to as construction or building rubble.

**Industrial operations material** - material from industrial operations is typically a by-product produced by an industrial activity that includes any surplus, unwanted or discarded material resulting from a manufacturing process at factories, mills, and so forth.

**Mining operations material** - material from mining operations generally consists of unprocessed surplus overburden material or non-ore bearing material that was removed and stockpiled during the mining operation. It is generally not compliant for direct use in the road layers, and requires removal of unwanted material, crushing and screening, and selection as applicable.

**Hazardous material** - contains organic or inorganic elements or compounds which may have a detrimental impact on health and the environment owing to the inherent physical, chemical, toxicological, radioactive or carcinogenic characteristics of the material.



**Construction and demolition material before**



**Construction and demolition material after**



### A4.5.3 GENERAL

The use of alternative materials may be specified in the Contract Documentation or be proposed by the Contractor. These alternative materials could be used on their own or mixed (blended) with additional imported material or with reclaimed road materials.

Before using any alternative materials, compliance with the following properties as applicable shall be ascertained:

- The **durability** of the material.
- **No deleterious minerals or hazardous material and chemicals** present.
- The **strength characteristics** for relation to the proposed use of the material, such as ACV, 10 % FACT, CBR, ITS and the like.

Sufficient tests shall be carried out to verify appropriate compliance with the above aspects and to ensure that the alternative material is compliant for its intended use in the earthworks or pavement layers.

For alternative materials identified by the Employer, initial negotiations or enquiries shall be conducted by the Employer about the availability of the material, price and conditions for procuring. The Employer may then decide to procure the material, where after the Contractor shall be responsible for producing, stockpiling and delivery of the material to the road.

Alternatively, when specified in the Contract Documentation, the Employer will not procure the alternative material and the Contractor shall be responsible for all contractual and legal matters pertaining to ordering, processing, stockpiling, loading, delivering and paying for alternative materials obtained from any alternative sources.

The Contractor shall also ensure that the site, property and the works where the material is sourced comply with all the applicable safety requirements.

### A4.5.4 DESIGN BY THE CONTRACTOR / PERFORMANCE BASED SYSTEMS

Should the Contractor wish to propose the use of any alternative materials to replace the specified materials then sufficient laboratory test results, together with a method statement stating how the material will be sourced, placed and processed, shall be submitted for review to the Engineer to determine that the Contractor's proposal meets the Employer's requirements.

There are no performance based systems required for Section A4.5.

### A4.5.5 MATERIALS

#### A4.5.5.1 General

The material specifications given in Clause A4.1.5 shall also apply to any alternative materials produced for use in the earthworks and pavement layers. These material specifications are the required specifications for the alternative materials finally processed and placed in the road. Crushing and screening or modification, etc of the materials may be required to comply with these specifications.

#### A4.5.5.2 Construction and demolition material

The various types of construction and demolition material compliant for use in earthworks and pavement layers are given in Table A4.5.5-1.

**Table A4.5.5-1: Usage of construction and demolition material**

Type of material	Appropriate usage
Crushed concrete	Fill layers, the selected and possibly the subbase layers if the grading is compliant or when the grading can be improved by the addition of other approved material
Broken concrete and clay bricks and mortar, mixed crushed bricks, concrete and clay roof tiles, and glass	Fill and selected layers
Uncrushed concrete and hard burnt clay bricks	Pioneer layer

Construction and demolition material to be used for the construction of earthworks and pavement layers shall not contain any of the following materials:

- Timber,
- Reinforcing steel or mesh, steel, iron or other scrap metal,
- Asbestos products,
- Plastic and PVC materials,
- Dry walling materials,
- Pipes,
- Aluminum,
- Window and door frames,
- Laminated glass,
- Slate roof tiles,

- Electrical fittings,
- Insulation materials, and
- Carpets.

All such contaminant materials shall be removed before the material is produced by crushing, if applicable, loaded and hauled to the road.

#### **A4.5.5.3 Industrial operations material**

Material obtained from Industrial operations containing organic materials, textiles, plastics, petroleum products, hazardous chemicals or any other deleterious material (metals, sludge and so forth) shall not be used.

Materials from industrial operations that have a record of being used are detailed below.

##### **a) Slag from the production of ferrous and non-ferrous materials**

Some industrial slags may be compliant for **use in fill layers, the selected and the subbase layers**, either on their own or blended with sand or gravel or soil material. Slag is generally not compliant for a crushed stone base layer due to the porosity and high surface voids of the slag.

The most common industrial slags are granulated **blast furnace slag and steel slag** from the production of iron and steel respectively. Granulated **blast furnace slag is a stable material** and generally does not require weathering as it does not contain free lime (CaO). However, unlike blast furnace slag, steel slag shows volumetric instability mainly due to the presence of free magnesium oxide (MgO) and free lime (CaO). In the presence of water, these compounds hydrate expansively.

Due to its expansive properties the **use of steel slag shall not be considered in the works unless** conditions pertaining to its use are agreed to. When steel slag is proposed, the Contract Documentation shall include the expansion tests to be carried out and what test limits shall apply for the proposed use of the steel slag, and any pre-treatment that may be required.

##### **b) Ash**

Ash from coal burning power plants is generally **compliant for fill layers**. It may also be compliant for the **pavement layers of lower category roads, or for the wearing course of unsealed roads**. However, the properties of ash vary considerably from one source to another, and any ash proposed for use in the works shall be tested for compliance with the relevant material specifications given in Clause A4.1.5.

**Pulverised fuel ash (PFA), also known as fly ash, is a very fine material that is difficult to compact and may liquefy under wet conditions.** It may be compliant for use in fill provided the necessary precautions are taken during the placing, processing and compaction operations but it shall not be used without the written approval of the Engineer.

**Furnace bottom ash (FBA) can generally be used for fill layers and possibly for the lower pavement layers.**

Ash generates dust that shall be contained during transport, placing and compaction.

#### **A4.5.5.4 Mining operations material**

Material obtained from mining operations **shall be free from hazardous material and other unwanted materials** such as timber, metal, plastic or organic substances. The material shall also comply with the specifications for **deleterious minerals** in Clause A4.1.5.17. Depending on the material quality and the grading of the material it can be compliant for use in fill layers and in the pavement layers.

As it comprises sand, gravel or rock or a combination of these natural materials, it shall be used in the same manner as any other naturally occurring road construction material.

Stockpiles of material left over from the ore processing operations and mine dumps are generally non-compliant for use due to their fine grading and the chemical contamination that is often present.

##### **A4.5.5.5 Hazardous material (Additional note: not referred to as waste)**

The following materials are considered hazardous in road construction, and shall not be used in the works or be present in any of the layers:

- Acid in liquid form,
- Free asbestos,
- Animal carcasses,
- Batteries,
- Chemicals and containers,
- Disinfectants,
- Fertilizers,
- Fireworks,
- Fuel,
- Gas cylinders,
- Insecticides and pesticides,
- Medical waste,
- Oils,
- Paint and solvents,
- Pharmaceuticals,
- Radioactive material, or

- Weed killers.

#### **A4.5.5.6 Quality of materials**

It is the Contractor's responsibility to ensure that the alternative material including the furnishing, loading, hauling, further stockpiling if applicable, shall comply with the material specifications.

Any approval or consent given previously for the use of any alternative material shall be withdrawn, when the material no longer complies with the specifications anymore.

### **A4.5.6 CONSTRUCTION EQUIPMENT**

Construction equipment to source the alternative materials shall comply with requirements of Clause A1.2.6 of Chapter 1.

### **A4.5.7 EXECUTION OF THE WORKS**

#### **A4.5.7.1 Separation and selection of material**

Compliant road construction material shall be separated from unwanted contaminant material specified in Clause A4.5.5.2 and hazardous material in Clause A4.5.5.5. The road construction material shall have no visible signs under the naked eye of any unwanted material.

Material that is too large for acceptance by the crusher, such as pieces of concrete, shall be broken down to smaller sizes by conventional or handheld equipment.

#### **A4.5.7.2 Producing the material by crushing and screening**

Alternative materials, except ash and slag material from commercial suppliers, are seldom compliant for direct use in the road. It will generally require crushing, or screening, or crushing and screening.

For producing by crushing or by crushing and screening, and for the stockpile of the produced alternative materials, Clauses A4.1.7.2k) and A4.1.7.3 respectively shall apply.

#### **A4.5.7.3 Use of the material**

The Engineer shall have full control of the use of all alternative materials. The Contractor shall plan the operations and particularly the separation of unwanted material, breaking down of oversize material, and crushing and screening, in such a manner that any alternative material is used to the best advantage of the Employer. This means that no material shall be unnecessarily processed, produced or hauled.

### **A4.5.8 WORKMANSHIP**

The Engineer and the Contractor, shall determine and agree on the testing protocol and frequency of the applicable process control tests on any alternative material being used, to ensure that the quality of the materials produced complies with the specified requirements for the particular layer for which it will be used.

In addition to the standard tests used for the testing of earthworks and pavement layers materials, the following material tests shall be carried out where applicable:

- Chemical analysis by a recognised chemical laboratory to determine the presence and quantity of deleterious minerals and hazardous material.
- Determine the amount of expansion and degree of disintegration of the material when immersed in water for a prolonged period. The required soaking period will depend on the particular material.
- Hardness and durability tests depending on the use of the material. The relevant material properties specified in Clause A4.1.5 shall be applicable unless otherwise specified in the Contract Documentation.
- Determine the presence of unwanted material and hazardous material listed in Clauses A4.5.5.2 and A4.5.5.5 respectively.

Measurement, testing, and evaluation of all individual components and constructed products shall be in accordance with the methods prescribed in this Section or in Chapter 20 as relevant.

## C4.5 ALTERNATIVE MATERIALS

### 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 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 and paid for separately and the Contractor shall include the cost thereof in other items as deemed appropriate:

1. Taking of samples and laboratory testing of alternative materials identified by the Contractor to prove compliance with the specified properties.
2. For alternative materials identified and sourced by the Contractor, the removing of unwanted contaminant and hazardous material, breaking down oversize material, crushing, screening and separation, all as required, and for loading, hauling and off-loading.

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

- **Alternative materials identified by the Employer**

For alternative materials that must still be separated, cleaned, broken down, produced by crushing or crushing and screening as applicable, and then stockpiled, measurement and payment shall be made according to the applicable items in Section C4.1. Procurement of the material by the Contractor, if specified in the Contract Documentation, shall be paid separately in item C4.5.3 hereunder. Loading and hauling the material to the road shall be measured and paid for in Chapter 5.

Alternative materials that are already produced into the correct gradation compliant for use in the road layers and that are sold as a commercial material, shall be measured and paid for in accordance with Section 4 item C4.4.1. The cost for procuring the alternative material, for loading and hauling it to the road shall then be included in the tendered rate.

- **Alternative materials identified and sourced by the Contractor**

Alternative materials identified and sourced by the Contractor shall be measured and paid for in accordance with item C4.4.2 as for commercial materials. Procuring the alternative material, producing, crushing and/or breaking down and stockpiling as required, for loading at the source and hauling it to the road irrespective of the haul distance shall then be included in the tendered rate.

#### (iv) Items specifically for this Section of the specifications

Item	Description	Unit
<b>C4.5.1</b>	<b>Additional material investigations</b>	
C4.5.1.1	Cost of sampling and laboratory testing	provisional sum
C4.5.1.2	Handling cost and profit in respect of item C4.5.1.1	percentage (%)
Item	Description	Unit
<b>C4.5.2</b>	<b>Removing unwanted material from alternative materials identified by the Employer</b>	
C4.5.2.1	Contaminant material	provisional sum
C4.5.2.2	Handling cost and profit in respect of item C4.5.2.1	percentage (%)
C4.5.2.3	Hazardous material	provisional sum
C4.5.2.4	Handling cost and profit in respect of item C4.5.2.3	percentage (%)
Item	Description	Unit
<b>C4.5.3</b>	<b>Cost to procure alternative materials identified by the Employer</b>	
C4.5.3.1	Cost of procuring	provisional sum
C4.5.3.2	Handling cost and profit in respect of item C4.5.3.1	percentage (%)

QUESTIONS?

END OF DAY 1

Enjoy the evening and have a good night rest!