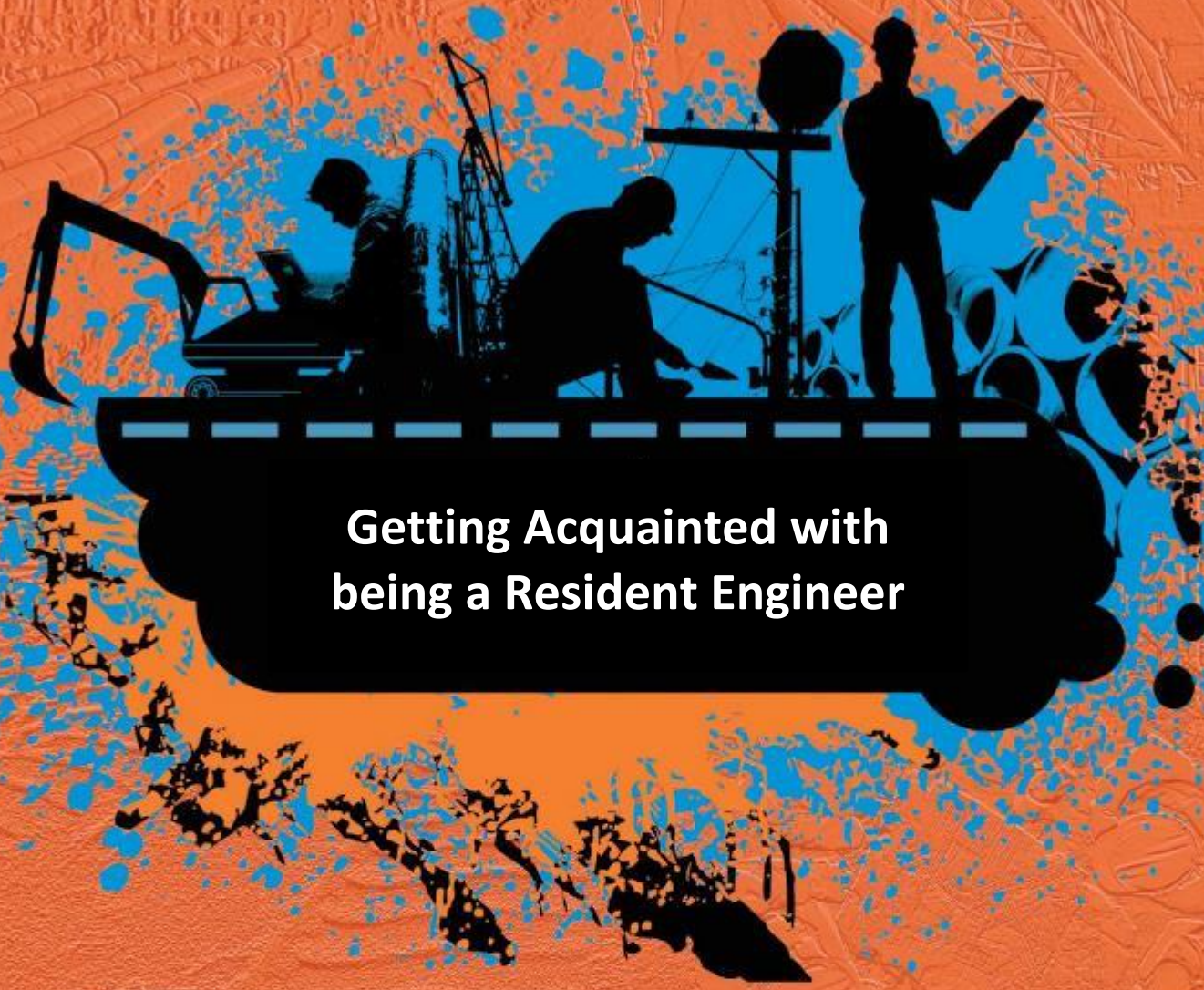

Getting Acquainted with being a Resident Engineer

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GETTING ACQUAINTED WITH BECOMING A RESIDENT ENGINEER

This training manual seeks to provide a guide for Resident Engineers, pertaining to their function, role, and responsibilities on site. Additionally, the manual will assist in being proactive with ethical evaluation and fair judgement.

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Contents

INTRODUCTION 1
1. ROLE PLAYERS 3
2. CONSTRUCTION PROJECTS 7
3. THE COMMUNITY 12
4. RESIDENT ENGINEER 14
5. ESTABLISHMENT 17
6. QUALITY CONTROL 23
7. TRAFFIC ACCOMMODATION 37
8. PATCHING 40
9. SERVICES & CULVERTS 43
10. DRAINAGE 54
11. CONCRETE 58
12. EARTHWORKS 65
13. STABILISATION 79
14. CRUSHED STONE 94
15. GRAVEL WEARING COURSE 104
16. PRIME 107
17. SEAL 111
18. SLURRY 130
19. ASPHALT 135
20. ROAD MARKING 144
21. COMPLETION OF PROJECT 147
22. SITE SUPERVISION 149
23. FINANCE 155
24. PROJECT MANAGEMENT 167
REFERENCES 178

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Contents

APPENDICES 181

APPENDIX A: QUALITY CONTROL PLAN 181

APPENDIX B: REGISTERS 182

APPENDIX B1: MISCELLANEOUS REGISTER 182

APPENDIX B2: CONCRETE REGISTER 183

APPENDIX B3: CULVERT AND SERVICES REGISTER 184

APPENDIX B4: LAYER WORKS REGISTER 185

APPENDIX B5: CRUSHED STONE REGISTER 186

APPENDIX B6: PRIME, SEAL, FOG SPRAY REGISTER 187

APPENDIX B7: SLURRY REGISTER 188

APPENDIX B8: ASPHALT REGISTER 189

APPENDIX B9: NON-CONFORMANCE REGISTER 190

APPENDIX C: LABORATORY TEST REQUEST – SOILS 191

APPENDIX D: LABORATORY TEST REQUEST – ASPHALT 192

APPENDIX E: INSPECTION REQUESTS 193

APPENDIX E1: MISCELLANEOUS INSPECTION REQUEST 193

APPENDIX E2: CONCRETE INSPECTION REQUEST 194

APPENDIX E3: CULVERTS AND SERVICES INSPECTION REQUEST 195

APPENDIX E4: LAYER WORKS INSPECTION REQUEST 196

APPENDIX E5: CRUSHED STONE INSPECTION REQUEST 197

APPENDIX E6: SEAL INSPECTION REQUEST 198

APPENDIX E7: SLURRY INSPECTION REQUEST 199

APPENDIX E8: ASPHALT INSPECTION REQUEST 200

APPENDIX F: NON-CONFORMANCE FORM 201

APPENDIX G: STATISTICAL ANALYSIS – STABILISATION 202

APPENDIX H: STATISTICAL ANALYSIS – CRUSHED STONE 203

APPENDIX I: STATISTICAL ANALYSIS – ASPHALT 204

APPENDIX J: CHECKLISTS 205

APPENDIX J1: CONCRETE SIDE DRAINS CHECKLIST 205

APPENDIX J2: SUBSOIL DRAINS CHECKLIST 206

APPENDIX J3: SERVICE DUCTS CHECKLIST 207

APPENDIX J4: KERB AND CHANNEL CHECKLIST 208

APPENDIX J5: CULVERT PIPES CHECKLIST 209

APPENDIX J6:PRE-CONCRETE CHECKLIST 210

APPENDIX J7: CONCRETE CHECKLIST 211

APPENDIX J8: POST-CONCRETE CHECKLIST 212

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APPENDIX J9: LAYER WORK CHECKLIST 213
APPENDIX J10: STABILISING CHECKLIST 214
APPENDIX J11: CRUSHED STONE CHECKLIST 215
APPENDIX J12: PRIME CHECKLIST 216
APPENDIX J13: PRE-SEAL CHECKLIST 217
APPENDIX J14: SLURRY CHECKLIST 218
APPENDIX J15: ASPHALT CHECKLIST 219
APPENDIX J16: ROAD MARKINGS CHECKLIST 220
APPENDIX K: WORKSHEETS 221
APPENDIX K1: CONCRETE WORKSHEET 221
APPENDIX K2: CULVERT WORKSHEET 222
APPENDIX K3: BITUMEN STABILISED LAYERS WORKSHEET 223
APPENDIX K4: STABILISATION (BULK) WORKSHEET 224
APPENDIX K5: SEALWORK WORKSHEET 225
APPENDIX K6: SLURRY WORKSHEET 226
APPENDIX K7: PAVING ASPHALT WORKSHEET 227
APPENDIX L: EXAMPLE OF LEVEL AND THICKNESS CONTROL 228
APPENDIX M: TRAFFIC INSPECTION 230
APPENDIX N: EXAMPLE OF SITE INSTRUCTION 231
APPENDIX O: REQUEST FOR INFORMATION 232
APPENDIX P: TECHNICAL QUERY 233
APPENDIX Q: EXAMPLE FOR TEMPLATE OF SITE DIARY 234
APPENDIX R: EXAMPLE OF WEEKLY MEETING 235
APPENDIX S: TEMPLATE FOR BILL OF QUANTITIES 236

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Contents

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INTRODUCTION

This manual is a guide for Resident Engineers, pertaining to their function, role and responsibilities on site. Application of the guidance provided herein will ensure that a good quality system is implemented, risk is limited, and will assist in working with the Contractor while focusing on important matters. Most importantly, the manual will assist in being proactive with ethical evaluation and fair judgement.

Application of the guidelines given in this manual will help the Resident Engineer to engage effectively with the Contractor and achieve optimum levels of productivity. The term *Resident Engineer* has been replaced in many documents, such as the GCC, where the Resident Engineer is now known as the *employer's agent's representative*, in FIDIC now known as the *Engineer's Representative*, and in NEC known as the *Supervisor*. The term *Resident Engineer* will be used throughout this manual for consistency.

Site dynamics

There is an inherent conflict between the Resident Engineer and the Site Agent, as one focuses on quality, and the other focuses on profit. It may seem like focusing on good quality may take longer and reduce profit, which can cause friction between the two parties. The truth is that both could be achieved, by knowing what is required, getting it right the first time, and resolving disputes fairly and timeously.

Increasing production without good quality may be very costly when work needs to be redone.

See the table below for typical mistakes made by both the Contractor and the Consultant on road construction projects, which can be costly and/or cause delays if not handled correctly:

Contractor's mistakes	Consultant's mistakes
Damage to existing services	Access to work delayed due to unsuccessful negotiations with 3rd parties
Culvert outlet level constructed too high	Unknown service not shown on the drawings, causing a delay with drainage
Constructed level of selected layer too low	Base density shown as 98% in the drawing, yet stated as 95% in the schedule of quantities
Second pavement layer constructed before the first pavement layer was approved/tested	Material from borrow pit not enough, or not good enough for intended purposes
Contractor not attending to unsafe excavation for a pipe culvert timeously	Unsuitable material or excavation of hard material not allowed for in the schedule of quantities
Execute work not using the latest revised drawing	New road design level does not tie-into existing road level

If the Consultant is too strict on unimportant matters, the Contractor will start disputing and claiming for every mistake on the drawings, schedule of quantities, and project specifications. When he is losing money, he will start taking short cuts and delivering bad workmanship, while hiding all mistakes from the Consultant.

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This normally results in the Resident Engineer and the Site Agent sitting in their offices writing accusatory and defensive letters, while the work on site is neglected.

If the Consultant is too lenient at the start of the project, setting a poor standard, and becoming 'good friends' with the Contractor, the quality of the work deteriorates, and it is very difficult to regain control and ensure the required standard is achieved. The Resident Engineer then loses control over the site; being manipulated or dominated by the Site Agent and his foreman.

The key is to be strict in the beginning, focusing on the important matters, and being reasonable and fair. The Consultant should be working together with the Contractor to resolve mistakes from both sides, using the give and take principle. The Resident Engineer must use their engineering judgement when work does not comply with the specifications, taking all factors into account before accepting, rejecting, or proposing remedial actions to work done. Contractors will provide better quality work and put in extra effort if they know what is required, are treated fairly and paid accordingly.

For this to work, the Resident Engineer must know what he/she wants, timeously communicate it to the Contractor, be fair in his/her judgement, and manage the project holistically. More can be achieved much quicker with limited frustrations, rejections, claims and disputes. Working as a team to resolve problems, instead of hiding mistakes and blaming each other for delays and mistakes will both limit the risk and increase production and quality. This manual covers all the elements that will be encountered on site, the possible challenges, and how to handle them; and will serve as a guide to achieve the productivity and quality goals.

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1. ROLE PLAYERS

The main role players on a construction site are:

1. The Client
2. The Engineer
3. The Contractor

Other role players are:

1. The Community
2. The Laboratory
3. Third parties, e.g., Eskom, Telkom, Municipalities, Metro police, landowners, etc.

It is essential for the Resident Engineer to understand the role and focus and function of each of the role players when proposing a solution to a problem where more than one party is involved or to reach an agreement between the parties as quickly as possible for the successful completion of the project. Let's look at the role, function and focus of each party.

1.1. The Client

The client is the entity that wants the road, bridge, drain, or pipeline built and provides the funds to build it.

Examples of clients:

1.	National Roads	SANRAL
2.	Provincial Roads	Western Cape Government, Gauteng Province Department of Roads and Transport, Road Agency Limpopo, Free State Provincial Government, etc.
3.	Municipalities	City of Cape Town, Tshwane Municipality, etc.
4.	Private Developments	Mining companies, private developers, etc.

1.1.1. FUNCTION

The Client's aim is to use the allocated funds to develop, build and maintain quality infrastructure in their various regions/facilities.

1.1.2. INTEREST AND FOCUS

Their focus is job creation, BEE development and long-term infrastructure.

1.2. The Consultant

The Consultant is appointed by the Client to investigate and design new infrastructure or upgrade or rehabilitate existing infrastructure. The Consultant will write a design report, outlining the proposed solution. The consultant will also draw up the document for contractors to tender for the project. The consultant will normally also supervise the construction of the road and manage the execution of the project.

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1.2.1. FUNCTION

The function of the Consultant is to investigate, analyse, and design solutions for specific areas/situations/problems, prepare tender documents, supervise (approve and reject work) and manage the changes (claims, disputes and technical issues) during the project, and write a close out report, along with as built drawings. The Consultant is also in charge of all the testing and analysing of test results.

Consulting Engineers tasks include:

1. Investigation
    a. Visual
    b. Test pits
    c. Historical data
    d. Special tests
2. Pavement design
    a. Traffic counts
    b. Material sources
3. Geometry design
    a. Horizontal alignment
    b. Vertical alignment
4. Design report
5. Tender document
6. Supervision
7. Project management.

1.2.2. INTEREST AND FOCUS

Consulting firms are professional organisations that take responsibility for their decisions and designs. They must carry professional indemnity insurance to cover the work they do, in case of claims made against them due to design or documentation errors.

Their interest and focus are quality and professionality. Their name and reputation are most important and therefore they will not take any unnecessary risks.

1.3. The Contractor

The Contractor tenders for the project. The tender is normally awarded to the lowest tenderer. The Contractor must have the relevant experience, size and BEE status as specified in the tender document.

The Contractor has all the plant, personnel, and systems in place to complete the project. Special works are normally subcontracted to a specialist.

1.3.1. FUNCTION

The function of the Contractor is to economically execute the work by managing the cash flow, material, plant and personnel on site. The Contractor has systems in place to complete the project.

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1.3.2. INTEREST AND FOCUS

The interest and focus of the contractor is profit. Experience, quality and managing risk plays a big role to ensure the contractor makes a profit on the project. A key success factor is employing the appropriate skills to execute the tasks.

1.4. The Community

The community plays a very dynamic role in the project. The community consists of the chief, the ward councillors, and the local people of the area.

1.4.1. FUNCTION

The function of the community leaders is to look after the people in the community, solve any disputes in the community, and promote justice.

1.4.2. INTEREST AND FOCUS

The interest and focus of the community leaders/ward councillors are to get votes and profit economically from the project. They will use the project to make money, using their influence and acting as the middleman between the supplier/subcontractor and the contractor. *"You must work through me"* is their slogan.

1.5. Third Parties

Third parties that are affected by the projects include:

1. Public
    a. Motorists
    b. Residents
    c. Farm owners
2. State Enterprises
    a. Railways
    b. Eskom
    c. Water boards
    d. *Municipality: water, sewer, or power
    e. Telkom
3. Private Enterprises
    a. MTN
    b. Vodacom
    c. Optic fibre providers.

Note: The municipality could be a third party in provincial projects, or the Client in municipal areas.

Important: These parties need to be informed timeously about the relocation, removal and any other agreement regarding their service, access, and interruption during the project!

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1.5.1. FUNCTION

The function of third parties is self-explanatory. The function of state and private enterprises is to provide a service to the public.

1.5.2. INTEREST AND FOCUS

The overall focus of state and private enterprises is to provide a good quality and uninterrupted service to the public.

1.6. Summary

FIGURE 1: THE MAIN ROLE PLAYERS

It is key for the RE to understand the focus of each role player when proposing or analysing changes or alternative methods.

Changes/New Proposal	Client/Community	Consultant	Contractor
Construct deviation road instead of STOP/GO closures	No flagman required, less jobs, lower cost	Safety vs risk of integrity of deviation road	New rates, profit
Use of asphalt at intersections over new seal work	More cost, new jobs	Less risk of seal damage	New rate, profit. Existing rate, no profit in small work
Add rehabilitation instead of patching section	Subcontractor less work	Better quality, less risk of bumps	Profit if work is not isolated
Improve drainage using grass blocks	Extra cost vs less maintenance, jobs	Less risk of erosion	New rate, profit

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2. CONSTRUCTION PROJECTS

The Client appoints the Consultant to solve a problem or perform a task, e.g., rehabilitation of an existing road or resolving a drainage problem. The Consultant investigates and makes proposals to the Client. This is called a feasibility study. The proposals are discussed with the Client. The Client will appoint the Consultant to do a preliminary design for the preferable proposal after considering the need, cost, and risks of each proposal.

Example of repairing an existing road:

The Consultant will investigate the condition of an existing road, through visual assessment and analysis of historical as built data. Proposals are made to reconstruct the existing road to last for a certain design period, normally 10 – 20 years, based on the road class.

The Client will then appoint the Consultant to do a detailed design. The Consultant will conduct further investigations by digging test pits and analysing material properties. A traffic analysis will also be done. After the detailed design is approved, the Client will advertise the project and it goes out the tender.

2.1. Contract Documents

The Consultant prepares the contract documents for the tender process.

One of the following standard conditions contracts will form part of the tender documents:

- FIDIC International Federation of Consulting Engineers
- JBCC Joint Building Contracts Committee
- NEC New Engineering Contract
- GCC General Conditions of Contract for Construction Works

The work will comply with one or more standard specification documents, e.g.:

- COTO/COLTO Standard Specifications for Road and Bridge Works for State Authorities
- SANS South Africa National Standards

The most common contract and specifications for road construction are GCC and COTO/COLTO.

The Consultant will add, delete, or change clauses in the standard documents for the specific project.

Additionally, Clients have specifications that they prefer, which are added in the project document by the Consultants.

Further, Consultants prepare specific drawings for the work to be done. Standard drawings from the Client are also included in the book of drawings.

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The Consultant will prepare a project document that consists of the following (usually printed in the following colours):

Description		Colour	Comments
The Tender			
Part T1	Tendering procedures		
T1.1	Tender Notice and Invitation to Tender	White	
T1.2	Tender Data	Green	
Part T2	Returnable Documents	White	
T2.1	List of Returnable Documents	White	
T2.2	Returnable Schedules	White	
The Contract			
Part C1	Agreement and Contract Data		
C1.1	Form of Offer	Pink	
C1.2	Form of Acceptance	Pink	
C1.3	Contract Data	Pink	See detail below
C1.4	Form of Guarantee	Pink	
Part C2	Pricing Data		
C2.1	Pricing Instructions	Yellow	
C2.2	Schedule of Quantities	Yellow	Bill of Quantities (BoQ)
Part C3	Scope of Work		
C3.1	Description	Blue	Overview and lab testing
C3.2	Engineering	Blue	Designs and drawings
C3.3	Procurement	Blue	Subcontractors, B-BBEEs, CPG*
C3.4	Construction	Blue	'B'** changes to COLTO & BoQ
C3.5	Management	Blue	
Part C4	Site Information		
C4	Site information	Blue	See detail below
Part C5	Annexures		

*CPG: Contract Participation Goal is the specified percentage of the contract price that must be spent on local labour, targeted enterprises, local enterprises, and emerging contractor development.

**'B' indicates changes made to the COLTO Standard Specification. The payment items that are affected in the Schedule of Quantities will also be marked with a 'B' prefix.

Example of changes in the COLTO and Bill of Quantities:

B3112 MEASUREMENT AND PAYMENT

Replace descriptions of items in 33.07 with:

"B33.07 Removal of unsuitable material (including free-haul of 1.0km):"

All references to a 0.5km free-haul distance must be replaced with 1.0km free-haul.

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Sometimes the following documents are included:

1. Materials Report
2. Services Report

The following information is specified in the Contract Data:

1. Changes to the General Conditions of Contract
2. Commencement of work
3. Access to site
4. Defects liability period, e.g., 12 months
5. Period to complete the project
6. Non-working times
7. Penalty for delay, e.g., R20 000 per calendar day
8. Delivery of security
9. Mark up percentage
10. Contract Price Adjustment (Labour, Plant, Materials, and Fuel)
11. Retention money, e.g., 5% or guarantee
12. Liability insurance, e.g., R20 million.

The following site information is given under Part C4:

1. Description of existing road and access roads
2. Existing structures
3. Traffic data
4. Existing services
5. Details of service authorities and farm owners
6. Weather conditions
7. Material sources and construction water
8. Community and local enterprises
9. Topography.

The Consultant will issue a set of drawings for the tender process.

The tender documents that must be completed by the Contractor include the *agreement*, *contract data*, *pricing instructions*, and the *Bill of Quantities*.

Amendments could be made to the agreement after evaluation of the tenders to clarify, or correct mistakes. These changes are minutes, and counter-signed.

There may be contradictions or discrepancies between the project document, the drawings, and the Bill of Quantities. This must be cleared with the Engineer and an instruction must be issued, indicating which document needs to be changed. For evaluation of claims, the hierarchy of documents as listed in the project document must be used, see GCC clause 2.4.2.

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Example of hierarchy of documents:

1. Form of Offer and Acceptance
2. Special Conditions of Contract
3. General Conditions of Contract
4. Scope of Works, including Project Specifications
5. General Specifications and Special Specifications
6. Drawings
7. All Schedules.

2.2. Awarding the Contract

After the tender documents are received, the Client normally awards the project to the lowest bidder that complies with all the criteria set out in the tender documents.

The contract, to construct at an agreed rate, within a certain period to a specified standard, is signed by the Client and the Contractor. The agreement states that the Client will pay for the work done as specified in the contract document. A penalty is normally applied for contracts that are not completed within the agreed period or specification.

The Client hands over the site to the Contractor to commence construction. The Contractor is now responsible for the safety of the public and motorists on that site.

Important: **There is no contract between the Consultant and the Contractor.**

The Consultant is a professional entity, and all decisions/rulings are made with integrity. The Consultant is thus a third party, advising the Client and supervising and managing the project on behalf of the Client. Contracts are set up in this manner to limit the possibility of the Contractor bribing the supervision team.

2.3. Contractual Matters

After the contract is awarded to the Contractor, the following is done:

1. The Client hands over the site to the Contractor via a letter.
2. The Consultant issues a set of construction drawings to the Contractor.
3. The Contractor submits the following documents:
    a. Insurance
    b. Performance Guarantees
    c. Letter of good standing from the Compensation Commissioner
    d. Tax Clearance Certificate
    e. Health and Safety Plan
    f. Occupational Health and Safety Agreement
    g. Programme to be Submitted by the Contractor

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4. The following persons are appointed:
    a. Resident Engineer
    b. Site Agent
    c. Site Safety Officer
    d. Designated Environmental Officer
    e. Community Liaison Officer
5. The working permit is obtained from the Department of Labour.

These contractual matters should be finalised within 14 days after the work permit was obtained.

These matters are normally formalised and finalised by the Engineer, the Contact Manager, and the Client's project manager. The Engineer would ask for the Resident Engineer's input for comments on the Contractor's programme.

2.3.1. DRAWINGS

Normally, two sets of A0 and A2 drawings are issued to the Contractor within a week or two after the contract is awarded. If these drawings are different from the drawings that were issued during the tender stage, the drawings should be clearly marked as ***"Issued for Construction"***. Tender drawings not used for construction should be marked ***"For Tender Purposes Only"***.

Important: The Engineer should keep a drawing and transmittal register. The Resident Engineer and site supervision staff should study the drawings and have a copy.

2.4. Contractor's Programme

The Contractor should normally submit the programme to complete the works within two weeks after the site has been handed over. This is a very important document and will serve as a basis for claims and disputes for any changes that might arise during the project.

Important: The following must be checked in the programme:

1. The traffic accommodation sequence must make sense and not overlap
2. The embargo period must be adhered to
3. Will there be any half width traffic accommodation during the December/Easter holiday?
4. The critical path must be clearly indicated
5. Production rates should be reasonable
6. Enough time should be allowed for:
    a. drying out of base before asphalt/prime
    b. drying of prime before seal
    c. drying of slurry before seal/road marking
    d. curing of asphalt before seal, and
    e. curing of fog spray before road marking
7. Allowance for testing and approval of mix designs
8. Allowance for trial sections
9. Allowance for rain days
10. Allowance for obtaining a work permit.

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3. THE COMMUNITY

The community plays an important part in the project. Many projects have been stopped by community leaders exercising their political power, or protests/riots. In certain areas of the country, community leaders tend to use the project for political gain.

Warning: In the past, ward councillors have spread rumours that they would give jobs to all of the people in the community during the project. They tend to make unrealistic promises in order to gain votes. These expectations not being met could lead to protests/riots.

Important: Invite the community leaders (councillors) of each ward for a meeting before the project starts. Inform them about the scope of the project, the amount of local labour expected to be employed, and what activities will be done by the SMMEs; this will prevent the creation of unrealistic expectations.

Key Point: Acknowledge ward councillors as community leaders and treat them with respect! This approach will be very beneficial.

Tips for Appointing Labour

1. It is advisable to use the unemployment list from the Department of Labour or the Municipality to source local labour. The list should be categorised for gender and youth in order to meet the requirements of the contract participation goal (CPG).
2. Not more than one person per household should be employed.
3. When no provision is made to provide a Community Liaison Officer, it is advisable to draw names from a box in the presence of the community, especially in areas of political unrest. Set up boxes as specified in the contract participation goal, e.g., youth male, youth female, adult male, adult female, disability. Draw the required number of names from each box. This may require some planning and organisation, but is well worth the effort.

3.1. Community Liaison Officer (CLO)

The main function of the Community Liaison Officer (CLO) is to source local labour for the project. The CLO is also the spokesperson for the community on the project, and the channel through which the employees could raise their grievances.

It is important to appoint the correct CLO, as he/she plays a key role in the fair appointment of labour on the project. A good CLO will prevent riots and will support the Contractor and the development process.

Danger: A biased CLO who selects only friends and family for jobs may be the cause of riots on site.

Key Point: The CLO should be a strong leader and respected in the community!

Tips for Appointing CLO

1. Set up a meeting with the community leaders before the project starts. Make sure that all wards are represented at the meeting.
2. Labour demand for the project should be discussed and split proportionally into the different wards.

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Scenario 1: No rivalry among community leaders, and the community leaders are respected by the community.

1. Explain that a CLO is required to represent the community on the project, and that all communication is to go through the CLO. The sourcing of local labour for the project will be the responsibility of the CLO. There is no political agenda for the appointment of labour.
2. Ask the ward councillors to provide proposals for the position of CLO, arrange for CVs to be provided, and choose the best candidate after interviewing the top five.

Scenario 2: Rivalry among the community leaders, and the community leaders are not respected by the community.

1. In areas of political unrest, it is important to be transparent, especially if the community does not have any faith in their leaders.
2. Organise a community meeting in the town hall and inform the community of the scope of the project.
3. Explain that a CLO is required to represent the community in the project, and that all communication is to go through the CLO. The sourcing of local labour for the project will be the responsibility of the CLO. There is no political agenda for the appointment of labour.
4. CVs for the CLO position must be submitted to the Contractor, not the ward councillors.
5. Advertise the position in the local newspaper and distribute pamphlets. All publications must be approved by the Engineer/Employer.
6. Select the top five candidates based on their CVs, and interview all of them before making the decision.

It is important to appoint an unbiased, respected Community Liaison Officer. If the CLO is not respected by the community, refer to point three in ***Tips for Appointing Labour.***

3.2. Project Steering Committee (PSC)

The Project Steering Committee (PSC) normally consists of the ward councillors and may include other community leaders. Each ward should be represented at the PSC. The PSC should not consist of more than 12 people. The function of the PSC is to discuss any issues the community wants to raise regarding the project through the CLO, for consideration at the monthly site meeting. The PSC should meet once a month.

Danger: Community leaders should not be allowed to attend the monthly site meeting, as this disrupts the meeting, and they tend to use it as a platform for the rivalry between the leaders.

Key point: Negotiations with the SMME and other subcontractors should not form part of the PSC meeting!

Tip: When dealing with SMMEs: Divide and conquer! Make a deal with each SMME separately.

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4. RESIDENT ENGINEER

Other names for Resident Engineer (RE) are 'Employers Agent's Representative', 'Principal Engineer', or 'Engineers Representative'. The Resident Engineer is permanently on site representing the Engineer and the Employer/Client. The Resident Engineer is usually a professional engineer and/or a person with many years of experience.

The Resident Engineer and the Contractor's Site Agent are the key persons on site through whom all information flows. The relationship between these persons is critical for the success of the project.

The Resident Engineer is also known as the 'Chief Inspector' and is the person who accepts and rejects work. This Resident Engineer is also the person who signs the payment certificate with the Engineer and the Contractor.

The focus of the Resident Engineer is to ensure the project is built to the specified standard and quality while looking after the interest of all third parties. The Resident Engineer also plays a key role in the management of the project.

The Assistant Resident Engineer is the person who assists the Resident Engineer with his tasks. This is normally an Engineer in training with limited site supervision experience. Other personnel that help the Resident Engineer with his tasks are Senior Materials Technicians (SMT), Material Technicians or the Clerk of Works. These persons do not always have a professional status but are experienced or qualified technicians. They are the eyes and ears of the Resident Engineer on site. Together they form the supervision team.

4.1. Ethics

The Resident Engineer is also the person who rejects works on site, and thus is not very popular with the Contractor. Friendship quickly turns sour when there is big money involved.

The Resident Engineer needs to find a balance between work and social events. Drinking a beer after work with the contractor, and becoming drinking buddies, may influence your decisions on site.

Key point: Keep your integrity. Keep your professional status as a professional engineer.

Danger: The Resident Engineer may lose his professional status if he does not execute his work professionally or with integrity. See ECSA Code of Conduct for more details.

Extracts from the Code of Conduct of Registered Persons, Engineering Profession Act no. 46 of 2000:

Registered persons should:

- Execute their work with integrity
- Encourage excellence within the engineering profession
- Not prejudice public health and safety
- Discharge their duties with due care, skill and diligence
- Only undertake work which rendered them competent to perform
- Not engage in any act of dishonesty, corruption or bribery
- Give engineering decision, recommendations or opinions that are honest, objective and based on facts.

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4.2. Duties

The main duties/tasks of the Resident Engineer on site could be summarised as:

- Keep and sign daily diary
- Liaise with third parties
- Visual inspection, testing, evaluation and acceptance/rejection of work
- Measure quantities, and sign the monthly payment certificate
- Issue site instructions
- Write minutes of site meetings
- Compile snag list
- Complete the As Built forms
- Write the Close out report.

See ***Appendix Q*** for a template of a site diary.

4.3. Responsibilities

The Resident Engineer is responsible for the quality of the work and ensures that all work is done according to the specifications. He oversees the sampling and testing of material. He is also responsible for the contract administration, cost control, and communication to all parties. He ensures the contractor abides by the law regarding the payment of wages and complying with environmental regulations, safety acts, and does not disrupt public traffic unnecessarily.

The responsibilities of the Resident Engineer include the following:

- Site supervision
- Monitoring progress and expenditure
- Quality control systems and implementation
- Approval of trial sections, establishing the quality of how things are done
- Project management
  – Solving technical matters
  – Advice on claims and disputes
- Agreeing on type and method of remedial work
- Communications to all parties
- Ensure safety
- Protection of the environment
- Acting in the public interest, e.g., traffic jams.

Refer to ***Chapter 22*** for details on site supervision.

As a professional engineer, the Resident Engineer should take responsibility for the safe and practical execution of the works. He/she should make observations of what was designed and what is required after being on site. He/she has a better 'feel' for what is needed when working on site and is obligated to make meaningful contributions while working on the project.

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Examples of meaningful contributions made by the Resident Engineer:

1. Move pipe culvert 10m to a low point of natural ground level and install at an angle that matches the flow of the water.
2. Install edge beams where taxis damage the edge of surfacing to pick up workers near the township.
3. Adjust the stone application that was specified in the seal design.
4. Install subsoil drains across the road to prevent recurring damage to the road pavement caused by underground water.
5. Propose an alternative deviation road, location, width, or pavement structure.
6. Add warning signs: children cross the road, horses/wild animals/cattle cross the road, or sharp bend in the road 60km/h.
7. Check and change bending schedules for reinforced concrete where required.

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5. ESTABLISHMENT

5.1. Communication Channels

The Resident Engineer and the Site Agent working for the Contractor are the key persons on site through which all information flows. It is essential that good records are kept, especially when it comes to claims and disputes on site.

The following communication channels are used on construction sites:

- Site diary
- Site instructions
- Site Correspondence book
- Emails
- Verbal instructions.

See ***Appendix N*** for a template of site instructions and ***Appendix Q*** for a template of a site diary.

Danger: Do not give instructions directly to labour for foreman; always communicate first to the Site Agent.

Key point: Diaries are of critical importance when evaluating claims. All delays, and plant breakdowns are to be recorded.

5.2. Site Diary

An official daily record of events is to be kept and signed by both Site Agent and the Resident Engineer.

The site diary should contain the following information:

- Brief description of major activities of work
- Plant and labour resources
- Major materials received
- Weather conditions in the morning and afternoon
- Delays and frustrations experienced
- Written and verbal instructions received
- Accidents and incidents.

Warning: The Contractor does not always include breakdown of plant in the site diary.

Important: Any delays, such as late deliveries of material, of establishment, of plant, or persons, should be noted in the RE's personal diary.

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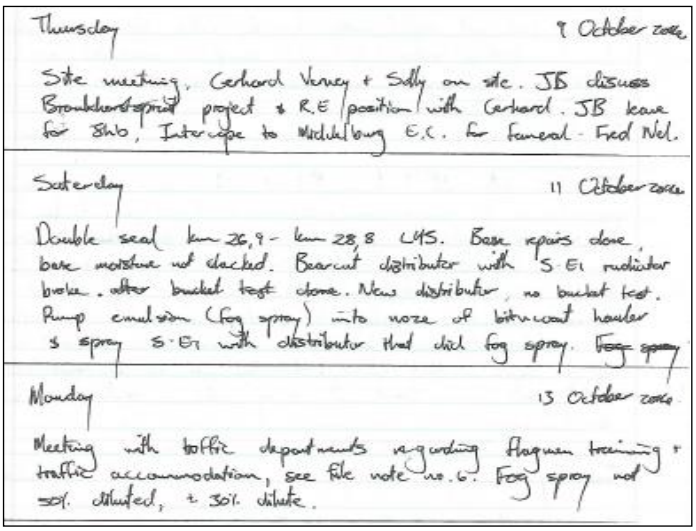
5.3. Personal Diary

It is good practice for the Resident Engineer and supervision staff to keep a personal diary of events. Information recorded in the personal diary should include the following:

- Critical observations made
- Comment on interpersonal relations
- Good ideas to be implemented
- Successes and failures – lessons learned
- Personal view of events and delays
- Photographic record very important, especially when evaluating claims.

Important: Use a normal book and draw line after each day to ensure that the personal diary clearly indicates the events of each day in case such evidence is required in court.

Example of personal diary that could be used in court. A line after each day indicates that nothing could be added afterwards:


Thursday 9 October 2006

Site meeting. Gerhard Verney + Sally on site. JB discuss Brandvlei project & R.E position with Gerhard. JB leave for Stlb, Intercape to Middelburg E.C. for funeral - Fred Nel.

Saterday 11 October 2006

Double seal km 26,9 - km 28,8 LHS. Base repairs done, base moisture not checked. Bearcat distributer with 5 E1 modifier broke. after bucket test done. New distributer, no bucket test. Pump emulsion (fog spray) into noze of bitumcoat hauler & spray 5 E1 with distributer that did fog spray. ~~Fog spray~~

Monday 13 October 2006

Meeting with traffic departments regarding flagmen training + traffic accommodation, see file note no. 6. Fog spray not 50% diluted, + 30% dilute.

FIGURE 2: PERSONAL DIARY

5.4. Site Instruction

Formal instructions are communicated through site instructions. All contractual issues and instructions that have a financial implication should be given with a site instruction.

Tips regarding site instructions:

- Refer to the clause in the Conditions of Contract from which the instruction derives its authority
- Refer to drawings, standard specifications, project document or previous site instructions
- It is important to indicate the applicable payment items
- Include the due date for performance if applicable
- Site Agent could reply to instruction.

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Note: Just because it is signed by contractor and dated, does not mean he agrees with the instruction.

Instructions relating to the following should always be issued as a written site instruction:

- % cement/emulsion or bitumen to be used for stabilisation
- Target grading of crushed stone
- Seal application rates after trial section
- Patching list
- Snag list
- Any changes made on the drawings
- Any changes made to the project document
- Any discrepancies in the project document, drawings or Bill of Quantities
- List of concrete side drains, subsoil drains, etc.

SITE INSTRUCTION	No. 4
	Date: 05-Mar-2020
Contract No: C1094	Contractor: Baseline Civil Contractors (Pty) Ltd
Contract Description:	The rehabilitation of main road 531 (km 78.0 to km 92.6, Elands Bay) and the periodic maintenance of main road 540 (km 0.0 to km 12.4, Leipoldtville)
Subject:	Stabilizing subbase of gravel shoulder temporary widening.
Phase 1 on drawing no. GD49/322 at the following locations refers: km 76,280 to km 78,320 RHS gravel shoulder 1m wide km 77,155 to km 77,160 RHS gravel shoulder 1m wide Required layer works: Cut top 150mm shoulder material and mix with 2% cement to be used as subbase. (Item 33.04, 35.01 a and 35.02 g) Cut and spoil 150mm subbase. (Item 33.04) Place and compact stabilized material as subbase; compacted to 93% of modified AASHTO density. (B34.04 c i) Import 150mm G5 material and compact to 95% of modified AASHTO density. (Item 15/B34.04 c i and 15/B34.06 b i)	
Resident Engineer: Jan Bierman	Sign: Signature Date: 05/03/2020
Payment Item No.	See above.
Comments:	
Received by Site Agent: Nel Kotze	Sign: Signature Date: 5 March 2020

FIGURE 3: SITE INSTRUCTION

Tip: Always communicate what is written in the site instructions to the foreman or team leader. Most times this information is not communicated by the Site Agent. Make sure it happens, to prevent mistakes!

5.5. Emails

E-mail has become common practice for communication on site.

Emails are useful because it can easily be sorted to ensure all outstanding issues are addressed. The search function is also very useful.

Advantages of emails are the following:

- Speed
- Disregard for office hours and location
- Ability to be copied to any number of recipients.

Danger: **E-mails do not replace a signed site instruction.** The date when the instruction was received is recorded on the site instruction and not on an email.

Tip: A good filing system is essential.

Guide for folders for e-mails

- Admin
- Correspondence
- Finance
- Meetings
- Traffic & safety
- Environment
- Services
- Drainage
- Patches
- Layer works
- Asphalt
- Seal
- Bridges
- Laboratory
- General

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5.6. Correspondence Book

It is good practice to separate instructions from other correspondence and the use of a dedicated, more formal, instruction book is recommended.

The traditional site correspondence book consists of a triplicate pen carbon book with a line drawn down the middle of the page – the contractor uses the one half and the Resident Engineer uses the other half. The purpose of the book is to record in writing all interaction of a contractual nature between the Site Agent and the RE, be it information, a request, a reply, a proposal, a notification, etc.

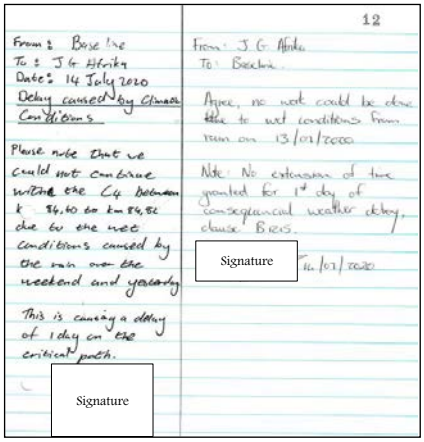

FIGURE 4: SITE CORRESPONDENCE BOOK

All entries by one party should be acknowledged by the other party. Foremen who do not have access to email or the internet can easily make use of the site correspondence book to ask for information etc.

5.7. Request for information (RFI)

Contractors make use of Request for Information forms to formally ask for information. The contractor signs the document, and the Resident Engineer will sign that he/she has received the request. The request is dated and referenced numerically.

There should be space for the Resident Engineer to comment on the request. The Resident Engineer may also forward the request to the Engineer or designer for comment.

The request for information is not always used on projects and could be replaced by sending an email. RFIs are normally used on big projects, multi-disciplinary projects, and projects where the Resident Engineer is not on site full time.

The RFI should have a note on how urgent the request for information is, e.g.:

- 1-2 days
- 3-4 days
- 5-7 days

FIGURE 5: REQUEST FOR INFORMATION

See ***Appendix O*** for an example.

5.8. Technical Query

Technical Queries are used to clarify disputes, obtain missing information, ask for approval for using alternative materials or methods from what was detailed in the project specifications or drawings, etc. The query could be raised by the Resident Engineer or the Contractor. The Resident Engineer will

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forward the Technical Query to the relevant party, e.g., Engineer, Structural Engineer, Designer, or Architect. The document will be dated and signed by the relevant parties.

On smaller projects technical queries could be issued via email. All the relevant parties must be copied into the email.

See ***Appendix P*** for an example of a Technical Query form.

5.9. Site Office

The Contractor must start establishing on site within one month after the contract has been awarded by the Client. The Contractor must provide offices for the Consultant's supervision staff and the laboratory. The Resident Engineer must approve the layout, quantity and quality of office equipment required. The Contractor must provide security for the offices.

Key point: Ensure the Contractor's office, supervision team's office and the laboratory manager's office are near each other. This is essential for good communications and smooth running of the project.

Danger: Do not locate the offices where there is weak cell phone signal.

Tip: Make use of two-way radios on site if the site is remote and cell phone signal is bad. Install a server to share files between the Laboratory, Consultant, and the Contractor.

5.10. Site laboratory

Laboratory services are commissioned or set up by the Consulting Engineer after the tender process has been followed.

Joint laboratory:

Usually, the Contractor proposes to use the same laboratory for his process control. The contractor usually contributes a bakkie and labour towards the joint laboratory. The laboratory and tests remain under the control of the Consultant. The Contractor may ask for additional tests for his own production control.

Warning: The MOD hammer footing needs to be strong, 30MPa. Brick footing is too weak and will influence the results.

The Troxler needs to be placed in a secure lockup cabinet.
Extractor fans are required for asphalt testing.

Tip: Allow for enough power to run all the ovens in the laboratory, ask laboratory manager for assistance.

Key point: No permanent works may start before the laboratory and site offices have been established.

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5.11. Payment

5.11.1. P&G'S

Payment items are numbered according to the clauses in the COLTO documents. In this manual, all payment item numbers refer to the COLTO specifications. Contractors preliminary and general fixed cost, item 13.01, is paid in three instalments.

Fifty percent is paid after establishment; thirty-five is paid after 50% of the contract value has been reached, excluding variation orders but before escalation; and the final 15% is paid when the completion certificate is issued.

The Contractor must satisfy the Engineer that he or she has provided camps and constructional plant of good quality on site that exceeds the value of the first payment of 50% for fixed obligations. The Contractor may be required to furnish documentary proof that he owns the camps and construction plant on the site.

Example of payment records:

Payment Item		Description	Unit	Rate	Quantity	Amount	
13.01 c		Contractor's general obligations Time related	Month	R 200 000	6	R 1 200 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	*1*	*October 2020*		*1*	*1*	*NK*	*JB*
25/11/20	*2*	*November 2020*		*1*	*2*	*NK*	*JB*
10/12/20	*3*	*December 2020*		*1*	*3*	*NK*	*JB*

5.11.2. OFFICE AND LABORATORIES

Eighty percent of the office and laboratory costs are paid at the beginning of the project; 10% after 50% of the contract value has been reached; and the last 10% when the offices and laboratories are de-established.

Example of payment item 14.01 c:

Payment Item		Description	Unit	Rate	Quantity	Amount	
14.01 c		Office and laboratory accommodation Open concrete working floors, 150 mm	m^2	R 300	50	R 15 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
02/03/20	*2*	*8m x 4m x 80%*		*25,6*	*25,6*	*NK*	*JB*
25/01/21	*13*	*50% of contract amount reached; 8m x 4m x10%*		*3,2*	*28,8*	*NK*	*JB*
25/08/21	*18*	*De-establish; 8m x 4m x 10%*		*3,2*	*32,0*	*NK*	*JB*

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6. QUALITY CONTROL

The Contractor is responsible for his own testing of materials (production control) apart from the acceptance control that is performed by the Consultant.

Production control: Regular tests done at fixed intervals by the Contractor as part of his own quality assurance, e.g., grading of G3 material at the crusher, density of asphalt using a Troxler.

Acceptance control: Random spot tests done by the Consultant as specified in the contract document for approval of material/works.

Most contracts make use of a joint laboratory for production and acceptance control. This eliminates the problem of two laboratories testing the same material with different results.

The contractor normally only does production control when they produce materials themselves e.g., crushed stone, asphalt and/or concrete. Commercial suppliers do their own quality control.

Important: The process/production control must be separated form acceptance control when using a joint laboratory, e.g., use different coloured paper, separate registers, and separate request forms.

6.1. Quality Control Plan

The Contractor must submit a Quality Control Plan for approval to the Engineer.

This plan details the system for testing and approval of all works.

The following need to be included in the plan:

1. All tasks to be performed during the contract
2. Mix design
3. Method statement
4. Trial sections
5. Inspection witness, testing and hold points
6. Surveys required
7. Test requests forms and registers to be completed
8. Numbering system for test requests
9. Checklists and worksheets to be completed
10. Testing frequency, and random test positions
11. Period for testing and approval.

See Appendix A for an example of a Quality Control Plan.

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List of registers to be completed by the Contractor:

1. Miscellaneous — ***Appendix B1***
2. Concrete — ***Appendix B2***
3. Culverts and Services — ***Appendix B3***
4. Layer works — ***Appendix B4***
5. Crushed Stone — ***Appendix B5***
6. Asphalt — ***Appendix B8***
7. Seal — ***Appendix B6***
8. Slurry — ***Appendix B7***
9. Non-conformance — ***Appendix B9***

See ***Appendix F*** for an example of a non-conformance report for work that was not accepted.

Laboratory tests and evaluation of test results are also given the respected Appendices.

Method statements should be submitted for each task.

Example of completed inspection request register:

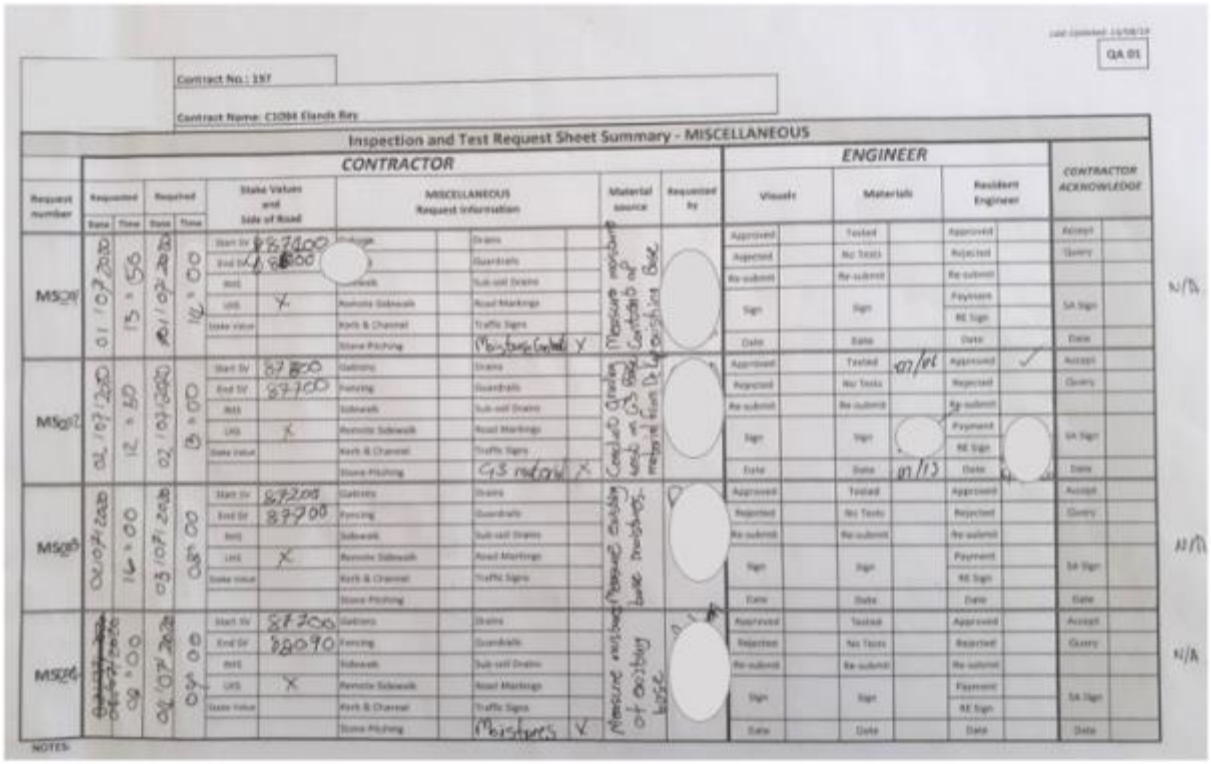

FIGURE 6: COMPLETED INSPECTION REQUEST REGISTER

Examples of registers, inspection requests, laboratory testing, and evaluation of tests are shown under the relevant chapters.

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6.2. Quality Control

Quality control involves monitoring laboratory tests to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory results.

Quality control is about maintaining the required quality standard and taking corrective action whenever a deviation becomes evident. Useful tools in this regard would be graphs of the moving average and trend lines of results obtained.

Source: *SANRAL Bridges and Structures Manual, paragraph 2.9.4 Quality Control page 2-24.*

Example 6.1: ETB patches

Subcontractor Saclawa is constructing emulsion treated base (ETB) patches on MR540 near Leipoldtville. The existing base failures were milled out. The material was stabilised in the workshop yard, three kilometres from the patches. ETB patches failed randomly in density.

Further investigation indicated that the ETB material becomes dry before it was compacted. The material was offloaded at various locations on the site. The patches done early in the day were still moist. As the sun dried out the outer course of the ETB stockpile, the density could not be achieved with the compaction equipment as the material was too dry to compact.

The construction method is to be changed, not the material or the equipment. Water is to be added before compacting the layer after 10h00.

Example 6.2: C4 subbase patches

Subcontractor Talon is constructing stabilised C4 subbase patches. The G3 base is covered with 35mm asphalt. The subbase density randomly failed.

Further investigation indicated that the subbase failed only in small patches. Larger patches were compacted with a Bomag 90 roller (walk behind). The small patches were compacted with a Wacker (jolly jumper).

All the small patches failed. This was because the roller was too light to compact a 150mm thick layer.

The method of constructing the layer must be changed. The thinner layer is to be constructed with light equipment, e.g., compact small patches in 50mm layer thicknesses. Plate compactors are not allowed for compaction of layer as it is too light.

6.2.1. QUALITY VS GRADE

The supervision staff must be careful not to confuse *quality* with *grade*. Grade is a category or rank given to entities having the same functional use but different technical characteristics. Low quality is always a problem; low grade may not be. For example, a formed concrete surface may be of high quality (hard durable and sound concrete surface) and low grade (as-stripped surface finish), or of low quality (powdery, blow holes or honeycombing) and high grade (high quality formwork panels for intended class F3 finish).

Source: *SANRAL Bridges and Structures Manual, Section 2.9.4: Quality Control, page 2-24.*

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Examples:

1. The density of a cement stabilised layer fails. The density was retested after two days and passed. This happens on each stabilised section. The moisture of the layer is low, and compaction is minimal. **Effect**: the cement stabilised layer stiffens after two days, giving better density results. The compaction equipment/method must be adjusted, and no re-testing done after 2 days.
2. The ITS results of bitumen stabilised layers are too low. Contractor adds more cement, and the ITS test results pass. **Effect**: the bitumen cement ratio is too low, and the layer is no longer performing as a BSM layer but a cement stabilised layer, affecting the life cycle of the pavement layer.

Quality control is more than the statistical analysis of test results, it is the verification and interpretation of test results, good and bad.

Danger: Tests results could be wrong due to incorrect sampling, damaged samples, drying of material, reheating of samples, etc. **The test results that you see on paper must reflect what you see on site.** Sitting in the office and accepting or rejecting results from the laboratory is a big mistake!

Example of honey combing of concrete:

CURING & COMPRESSIVE STRENGTH OF CONCRETE CUBES (SANS 5861/3, 5863)

DETAILS AS SUPPLIED BY CLIENT

ORIGIN	REQ-UIRED (MPa)	SLUMP (mm)	DATE REPORTED	CUBE NUMBER	DATE CAST	DATE TESTED	AGE DAYS	MASS (g)	COMPRESSIVE STRENGTH (MPa)
CH 78+600 @78+680 BLINDING RHS		120	06/04/2021	A00396	25/03	01/04	7	8160	22.0
		120	26/04/2021	A00398	25/03	22/04	28/	8120	32.0
				A00399	25/03	22/04	28/	8137	32.0
				A00697	25/03	22/04	28/	8146	31.5
								AVERAGE	32.0

FIGURE 7: CONCRETE TEST RESULT PASS

FIGURE 8: POOR QUALITY CONCRETE ON SITE

Example of laminations on base layer:

IN-SITU DRY DENSITY REPORT (SANS 3001: NG5,GR20,GR30)

Section	: CH76+900 RHS	Tested By	: MAROBA	Date Tested	: 02.06.2021
Layer Type	: SUBBASE	Compaction Energy	: MDD	Date Layer Compacted	: 02.06.2021

Position	Depth (mm)	Material Description	Maximum Dry Density (kg/m 3)	Optimum Moisture Content (%)	In-Situ Dry Density (kg/m 3)	Moisture Content (%)	Relative Compaction (%)
1	150	DORBANK + G5	2166	7,7	2167	4,0	100,0
2			2166	7,7	2136	6,4	98,6
3			2166	7,7	2123	6,4	98,0
4			2166	7,7	2146	6,0	99,1

FIGURE 9: DENSITY RESULTS PASS

FIGURE 10: POOR QUALITY ON SITE: LAMINATIONS

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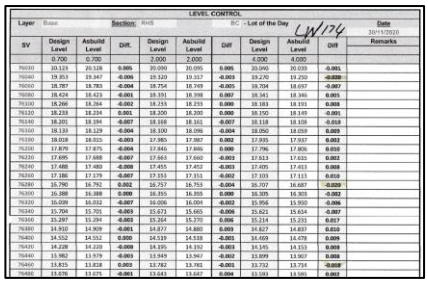
Example of levels and surface finish:



LEVEL CONTROL

Layer: Base	Section: RHS	BC - Lot of the Day	Date: 20/1/2020

SV	Design Level	Asbuild Level	Diff.	Design Level	Asbuild Level	Diff	Design Level	Asbuild Level	Diff	Remarks
	0.700	0.700		2.000	2.000		4.000	4.000		
76020	20.123	20.128	0.005	20.090	20.095	0.005	20.040	20.039	-0.001	
76040	19.353	19.347	-0.006	19.320	19.317	-0.003	19.270	19.250	-0.020	
76060	18.787	18.783	-0.004	18.754	18.749	-0.005	18.704	18.697	-0.007	
76080	18.424	18.423	-0.001	18.391	18.398	0.007	18.341	18.346	0.005	
76100	18.266	18.264	-0.002	18.215	18.215	0.000	18.183	18.191	0.008	
76120	18.233	18.234	0.001	18.200	18.200	0.000	18.150	18.149	-0.001	
76140	18.201	18.194	-0.007	18.168	18.161	-0.007	18.118	18.108	-0.010	
76160	18.133	18.129	-0.004	18.100	18.096	-0.004	18.050	18.059	0.009	
76180	18.018	18.015	-0.003	17.985	17.987	0.002	17.935	17.937	0.002	
76200	17.879	17.875	-0.004	17.846	17.846	0.000	17.796	17.806	0.010	
76220	17.695	17.688	-0.007	17.663	17.660	-0.003	17.613	17.615	0.002	
76240	17.488	17.480	-0.008	17.455	17.452	-0.003	17.405	17.413	0.008	
76260	17.186	17.179	-0.007	17.153	17.151	-0.002	17.103	17.113	0.010	
76280	16.790	16.792	0.002	16.757	16.753	-0.004	16.707	16.687	-0.020	
76300	16.388	16.388	0.000	16.355	16.355	0.000	16.305	16.303	-0.002	
76320	16.039	16.032	-0.007	16.006	16.004	-0.002	15.956	15.950	-0.006	
76340	15.704	15.701	-0.003	15.671	15.665	-0.006	15.621	15.614	-0.007	
76360	15.297	15.294	-0.003	15.264	15.270	0.006	15.214	15.231	0.017	
76380	14.910	14.909	-0.001	14.877	14.880	0.003	14.827	14.837	0.010	
76400	14.552	14.552	0.000	14.519	14.538	0.019	14.459	14.478	0.019	
76420	14.228	14.220	-0.008	14.195	14.192	-0.003	14.145	14.153	0.008	
76440	13.982	13.979	-0.003	13.949	13.947	-0.002	13.899	13.907	0.008	
76460	13.815	13.818	0.003	13.782	13.781	-0.001	13.732	13.714	-0.018	
76480	13.676	13.675	-0.001	13.643	13.647	0.004	13.593	13.595	0.002	

FIGURE 11: LEVELS OF BASE LAYER PASS

FIGURE 12: POOR SURFACE FINISH ON SITE

Example of asphalt core with large aggregate placed at the bottom of the mould. Damaged samples or incorrect tested samples should be omitted from the lot when analysing the results.

FIGURE 13: ASPHALT CORE WITH LARGE AGGREGATE

Example of asphalt density that is too low. The asphalt core should be inspected to confirm the low density; many small holes should be visible indicating a high void content. If the core appears to be dense, little to no holes visible, the core might have been damage during coring and should be re-tested.

FIGURE 14: ASPHALT WITH TOO LOW DENSITY

Examples of density tests reflecting what happened on site:

1. The density of a gravel layer fails on paper, but the construction method is good; possible causes: the Troxler test was not performed correctly, the Troxler was not calibrated daily, no sand was used to seat the Troxler properly, hole in the gravel layer was not straight, the correct MDD was not being used, the sample was not taken correctly, no moisture correction was done, there was a typing error.

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2. The density of a gravel layer passes on paper, but the layer is heaving or there are laminations or loose or soft spots. Possible causes: one good result due to rock in the layer increases the average density that it just passes the statistical criteria.

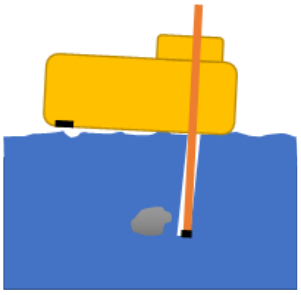

FIGURE 15: TROXLER TEST NOT DONE CORRECTLY

Important: Quality control is implementing good construction method, sampling, testing, and monitoring systems.

6.2.2. INSPECTION REQUESTS

The contractor must submit a request for inspection for each activity as indicated in the quality control plan. The inspection request should specify the date and location of the activity and when it will be ready for inspection.

These requests should be submitted the day before the inspection is required, not an hour or two before the concrete is cast etc. The laboratory should plan their testing according to the test request for the next day.

Certain inspection requests are just visual, e.g., reinforcing at bridges, guardrails, etc., while other inspections require testing of the material, e.g., layer works, asphalt, etc.

6.2.3. TEST REQUESTS

The consultant should issue a test request to the laboratory manager indicating what test should be performed, how many samples should be taken and at what location.

Locations are randomly selected; an Excel spreadsheet could be used to select random test positions. The Excel RAND() function returns a random number between 0,0 and 1,0.

See ***Appendix C*** and ***Appendix D*** for an example.

Testing of material is discussed under the relevant sections.

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6.2.4. APPROVAL OF INSPECTION REQUESTS

The inspection request should be approved after the following sections of the task have been inspected and evaluated:

1. Materials
2. Levels
3. Visual inspections

Comment for further testing or reason for rejection must be clearly written on the inspection request.

It is critical to communicate immediately to the Site Agent of any layer that failed or needs to be re-tested.

Tip: Inspection requests that fail should immediately be emailed to the Site Agent.

FIGURE 16: INSPECTION AND TEST SHEET

The inspection request should be rejected on paper and via email to ensure that all the parties involved can take the necessary actions quickly and minimise the effect on the overall project.

6.3. Statistical Analysis

The project document will specify which Quality Control Scheme should be used to evaluate test results.

COLTO 8300 Scheme 2: The table below specifies the average density and the minimum individual density.

Layer	Prescribed compaction	Unit of measurement	Mimimum average relative compaction for the following sample sizes						Minimum value for any single test for the following sample sizes					
			4	5	6	7	8	9	4	5	6	7	8	9
Selected layer	90%	Mod. AASHTO density	90.1	90.4	90.6	90.7	90.9	91	86.4	86.2	86	85.9	85.8	85.7
	93%	Mod. AASHTO density	93.1	93.4	93.6	93.7	93.9	94	89.4	89.2	89	88.9	88.8	88.7
	95%	Mod. AASHTO density	95.1	95.4	95.6	95.7	95.9	96	91.4	91.2	91	90.9	90.8	90.7
	100%	Mod. AASHTO density	100.1	100.4	100.6	100.8	100.9	101	96.4	96.2	96	95.9	95.8	95.7
Subbase	95%	Mod. AASHTO density	95.1	95.4	95.6	95.7	95.9	96	91.4	91.2	91	90.9	90.8	90.7
	96%	Mod. AASHTO density	96.1	96.4	96.6	96.7	96.9	97	92.4	92.2	92	91.9	91.8	91.7
	97%	Mod. AASHTO density	97.1	97.4	97.6	97.7	97.9	98	93.4	93.2	93	92.9	92.8	92.7
Gravel base	100%	Mod. AASHTO density	100.1	100.4	100.6	100.8	100.9	101	96.4	96.2	96	95.9	95.8	95.7
	98%	Mod. AASHTO density	98.1	98.4	98.6	98.7	98.9	99	94.4	94.2	94	93.9	93.8	93.7
	97%	Mod. AASHTO density	97.1	97.4	97.6	97.7	97.9	98	93.4	93.2	93	92.9	92.8	92.7
Crushed - stone base														
G1	88%	Apparent relative density	88.1	88.4	88.5	88.7	88.8	88.9	84.7	84.6	84.4	84.3	84.2	84.1
G2	85%	Bulk relative density	85.1	85.4	85.6	85.7	85.9	86	81.4	81.2	81	80.9	80.8	80.7
G3	98%	Mod. AASHTO density	98.1	98.4	98.6	98.7	98.9	99	94.4	94.2	94	93.9	93.8	93.7
G3	100%	Mod. AASHTO density	100.1	100.4	100.6	100.8	100.9	101	96.4	96.2	96	95.9	95.8	95.7
Asphalt base and surfacing	100%	(97-% voids in mix) % of theoretical density	100.1	100.3	100.5	100.6	100.7	100.8	97.1	96.9	96.8	96.7	96.6	96.5
Shoulders and wearing course	93%	Mod. AASHTO density	93.2	93.6	93.8	94	94.2	94.3	87.9	87.6	87.4	87.2	87	86.9
Plant-mixed pavement layers (Section 3700)	100%	Mod. AASHTO density	100.1	100.3	100.5	100.7	100.8	100.9	96.4	96.2	96	95.9	95.8	95.7

COLTO 8200 Scheme 1: Formulae are used to calculate the acceptance limit by adjusting the specified limit proportionally with the standard deviation. Outliers are checked and omitted.

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The following criteria and formulae are used to calculate the acceptance limit and accept/reject the lot:

Formula Acceptance limit	Accept lot when	Abbreviations
Single lower limit: **La = Ls + Sn.ka**	x_n>= La	$\mathcal{X}_n$: average
Single upper limit: L'a = L's – Sn.ka	x_n<= L'a	Sn : Standard deviation
Double lower limit: La = Ls + Sn.kad	x_n>= La	Ls : Specified lower limit
Double upper limit: L'a = L's – Sn.kad	x_n<= L'a	L's : Specified upper limit
Outlier To = $(x_0 - x_n)$/Sn > T;		Lr : Reduce payment limit
Outlier for asphalt & base course		La : Acceptance lower limit
Co = / $x_0 - x_n$ / > C		L'a: Acceptance upper limit

Reduced payments are applied only with consent with the Engineer. Limits for reduced payments are:

Compaction stabilised: Lr = La – 2.0%
Compaction asphalt: Lr = La – 1.0%
Concrete strength: Lr = 0,85.La
Asphalt binder: Lr/L'r = La -/+ 2.0%
Asphalt voids: Lr/L'r = La -/+ 0.3%
Cement content: Lr = 0.8.La
Payment factor is: fr = 0.67 + 0.3(xn – Lr)/(La – Lr)

A day's work is considered a lot.

The maximum percentage of defectives (ø) in an acceptable product are given in tables 8206/3/4/5.

Table 8206/3:

Material	Properties	Minimum sample size	Ls (Lower specification limit)	L's (Upper specification limit)	ø (%)
Selected subgrade	Relative compaction	4	90%, 93% or 95%		15
Subbase	Relative compaction	6	95% or 97%		15
Gravel base	Relative compaction	6	98% and if stabilised 97%		15
Crushed stone subbase/base	Relative compaction	6	See subclause 3602(a)		15
Asphalt base or surfacing	Relative compaction Binder Voids	6 6 4	See note 1	See note 1	15 15 15
Chemically stabilised layers	Cementitious binder content	10	See note 2	See note 2	10
Strength concrete structural	Compressive strength (28 days)	See table 8205/3	See notes 3 & 4		5
Pavement concrete	Compressive strength (28 days)	6	See subclause 7103(d)		5

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Tables for statistical analysis:

Table 8206/4	Ka Single limits		
n	5%	10%	15%
4	0.747	0.445	0.22
5	0.821	0.52	0.3
6	0.878	0.576	0.358
7	0.923	0.62	0.403
8	0.961	0.656	0.44
9	0.993	0.687	0.47
10	1.02	0.713	0.496
12	1.065	0.755	0.538
14	1.101	0.789	0.571
16	1.131	0.817	0.598
18	1.155	0.84	0.62
20	1.177	0.86	0.64

Table 8206/5	Kad Double limit
n	15%
4	0.22
5	0.3
6	0.358
7	0.403
8	0.44
9	0.47
10	0.496
12	0.538
14	0.571
16	0.598
18	0.62
20	0.64

Table 8206/5	Kr Single limit
n	15%
4	-0.148
5	-0.004
6	0.089
7	0.158
8	0.211
9	0.255
10	0.292
12	0.357
14	0.397
16	0.434
18	0.465
20	0.491

Table 8206/5	Krd Double limit
n	15%
4	-0.324
5	-0.130
6	-0.016
7	0.065
8	0.126
9	0.176
10	0.217
12	0.283
14	0.334
16	0.375
18	0.409
20	0.439

Table 8204(d)/1 Outlier			
Sample size (n)	T	Sample size (n)	T
3	1.20	15	2.41
4	1.46	16	2.44
5	1.67	17	2.47
6	1.82	18	2.50
7	1.94	19	2.53
8	2.03	20	2.56
9	2.11		
10	2.18		
11	2.23		
12	2.29		
13	2.33		
14	2.37		

Example 6.3: Statistical Analysis for 98% Base Density

Laboratory results for base density shown below:

IN-SITU DRY DENSITY REPORT (SANS 3001: NG5)

Section : 78+320-80+000 RHS Layer Type : BASE	Tested By : MAROBA Compaction Energy: MDD	Date Tested : 15.05.2020

Position	Depth (mm)	Material Description	Maximum Dry Density (kg/m^3)	Optimum Moisture Content (%)	In-Situ Dry Density (kg/m^3)	Moisture Content (%)	Relative Compaction (%)
78+380 / 0.7	150	C/GRANITE + SANDSTON	2134	7.3	1993	3.8	93.4
78+549 / 0.8	150	C/GRANITE + SANDSTON	2134	7.3	2121	2.8	99.4
78+666 / 0.7	145	C/GRANITE + SANDSTON	2134	7.3	2136	2.6	100.1
78+746 / 0.6	155	C/GRANITE + SANDSTON	2134	7.3	2032	3.0	95.2
79+003 / 0.4	150	C/GRANITE + SANDSTON	2134	7.3	2145	2.1	100.5
79+071 / 0.9	145	C/GRANITE + SANDSTON	2134	7.3	2119	2.6	99.3
79+283 / 0.4	150	C/GRANITE + SANDSTON	2134	7.3	2120	2.2	99.3
79+351 / 0.9	140	C/GRANITE + SANDSTON	2134	7.3	2138	2.9	100.2
79+525 / 0.0	150	C/GRANITE + SANDSTON	2134	7.3	2157	3.1	101.1
79+676 / 0.5	150	C/GRANITE + SANDSTON	2134	7.3	2127	3.0	99.7
79+838 / 0.6	150	C/GRANITE + SANDSTON	2134	7.3	1985	2.9	93.0
79+956 / 0.0	145	C/GRANITE + SANDSTON	2134	7.3	2116	2.3	99.2

Tests done by means of Nuclear method.

Required density 98%

Calculations:

Average density: $\bar{x}n = 98.4$

Standard deviation: Sn = 2.815

Number n = 12, ka (15%) 0.538; Table 8206/4

La = Ls + Sn.ka

La = 98 + 2.815 x 0.538 = 99.5

Result: $\bar{x}n = 98.4 < 99.5$ thus Fail

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Check for outlier

T = 2.29 (n = 12) Table 8204(d)/1

$T_0 = (\bar{x}0 - \bar{x}n) / Sn > T;$

Min 93.0

$T_0 = (93 - 98.4) / 2.82 = 1.92 < T;$

Max 101.1

$T_0 = (101.1 - 98.4) / 2.82 = 0.96 < T;$

$T_0 < T$ thus No outlier

Reduced payment

Lr = La – 2.0%

Lr = 99.5% – 2.0% = 97.5%

OK; average > 97.5%

$fr = 0.67 + 0.3(\bar{x}n - Lr) / (La - Lr)$

$= 0.67 + 0.3(98.4\text{-}97.5) / (99.5\text{-}97.5)$

$= 0.80$

Example 6.4: Statistical analysis for 97% base density

Laboratory results for base density shown below:

IN-SITU DRY DENSITY REPORT (SANS 3001: NG5)

Section : 80+000-81+500 RHS Layer Type : BASE	Tested By : MAROBA Compaction Energy: MDD		Date Tested : 15.05.2020

Position	Depth (mm)	Material Description	Maximum Dry Density (kg/m 3)	Optimum Moisture Content (%)	In-Situ Dry Density (kg/m 3)	Moisture Content (%)	Relative Compaction (%)
80+053 / 0.7	145	C/Granite + Sandston	2262	5.2	2182	3.1	96.5
80+205 / 0.8	150	C/Granite + Sandston	2262	5.2	2188	3.1	96.7
80+309 / 0.7	155	C/Granite + Sandston	2262	5.2	2193	2.9	96.9
80+380 / 0.6	150	C/Granite + Sandston	2142	7.1	2005	2.8	93.6
80+610 / 0.4	150	C/Granite + Sandston	2262	5.2	2218	1.6	98.1
80+670 / 0.9	155	C/Granite + Sandston	2262	5.2	2224	1.8	98.3
80+860 / 0.4	150	C/Granite + Sandston	2262	5.2	2214	2.2	97.9
80+920 / 0.9	150	C/Granite + Sandston	2262	5.2	2223	1.8	98.3
81+076 / 0.0	150	C/Granite + Sandston	2262	5.2	2198	1.6	97.2
81+210 / 0.5	150	C/Granite + Sandston	2262	5.2	2247	0.2	99.3
81+356 / 0.6	155	C/Granite + Sandston	2262	5.2	2201	2.4	97.3
81+460 / 0.0	145	C/Granite + Sandston	2262	5.2	2212	2.1	97.8

Tests done by means of Nuclear method.

Required density 97%

Calculations:

Average density $\bar{x}n = 97.3$

Standard deviation Sn = 1.418

Number n = 12

La = Ls + Sn.ka

La = 97 + 1.418 x 0.538 = 97.8

Result: $\bar{x}n = 97.3 < 97.8$ thus Fail.

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Check for outlier

T = 2.29 (n = 12) Table 8204(d)/1

$T_0 = (\bar{x}0 - \bar{x}n) / Sn > T;$

Max 99.3

$T_0 = (99.3 - 97.3) / 1.42 = 1.4 < T;$

Min 93.6

$T_0 = (93.6 - 97.3) / 1.42 = 2.6 > T;$

Result: $T_0 > T$ thus Outlier

Check for reduced payment

Lr = La – 2.0%

Lr = 97.8% – 2.0% = 95.8%

Average $\bar{x}n$ = 97.3% > 95.8% thus reduce payment

$fr = 0.67 + 0.3(\bar{x}n - Lr) / (La - Lr)$

$= 0.67 + 0.3(97.3-95.8) / (97.8-95.8)$

=0.90

Recalculate average excluding outlier

Average density excluding 93.6; $\bar{x}n$ = 97.7

Standard deviation Sn = 0.835

Number n = 11

La = Ls + Sn.ka

La = 97 + 0.835 x 0.517 = 97.4

Result $\bar{x}n$ = 97.7 > 97.4 thus Pass

Important: Visual inspection required at location of outlier to identify local soft spot to be repaired.

6.4. Interpretation of Test Results

Test results from the laboratory should not be blindly accepted and approved or rejected. The test results should be interpreted. Wrong sampling gives incorrect representation of the work that is done on site.

6.4.1. LAB RESULTS

Results from the laboratory should be investigated when they do not correspond with what is visually seen on site. Usually results that look suspicious should be retested. Ensure the sample was not damaged or taken at the wrong place. This is often the case; the field tester takes a sample from the windrow of the stabilised material instead of digging a hole in the compacted layer which is much harder.

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Good practice of taking samples:

- Take sample of stabilised layer after mixing but before compaction
- Take sample of concrete after discharging the first 1m^3
- The first five tons of asphalt that comes out of a drum plant should not be sampled
- Sampling of a stockpile should be done in the prescribed way, as the larger aggregate rolls to the bottom. The outside face should be removed before taking a sample. Sampling from the top digging deeper into the stockpile will be more accurate than sampling from the side at the bottom of the stockpile.

6.4.2. MOISTURE CORRECTION

The Troxler only reads the wet density accurately and not the moisture. The dry density is calculated by subtracting the moisture from the wet density to determine the dry density. The dry density is then used to calculate the percentage compaction compared to the dry density that was achieved in the laboratory with the Mod hammer.

A small sample should be taken from site, weighed, dried in the oven, and weighed again to determine the correct moisture of the material.

Example of calculating density after moisture correction:

IN-SITU DRY DENSITY REPORT (SANS 3001: NG5,GR20,GR30)

Section	: CH78+620 RHS	Tested By	: MAROBA	Date Tested	: 25.05.2021
Layer Type	: WEARING COURSE	Compaction Energy	: MDD	Date Layer Compacted	:

Position	Depth (mm)	Material Description	Maximum Dry Density (kg/m^3)	Optimum Moisture Content (%)	In-Situ Dry Density (kg/m^3)	Moisture Content (%)	Relative Compaction (%)
1	150	DORBANK + G5	2204	5.7	2155	4.6	97.8
2			2204	5.7	2165	4.1	98.2
3			2204	5.7	2154	5.0	97.7
4			2204	5.7	2162	4.6	98.1

Example of density for moisture correction +1.3% at position 1:

MDD 2 204kg/m^3 OMC 5.7%
Troxler DD 2 155 MC 4.6%
Density 2 155/2 204 = 97.8%
Correct moisture is 5.9% (4.6%+1.3%)

Calculation of correct density:

Moisture 2 155 * 4.6% = 99
Wet density 2 155 + 99 = 2 254
Dry density 2 254 / (1 + 5.9%) = 2 128
Density 2 128 / 2 204 = 96.5%

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Example of density for moisture correction -0.9% at position 3:

MDD 2 204kg/m^3 OMC 5.7%
Troxler DD 2 154 MC 5.0%
Density 2 154 / 2 204 = 97.7%
Correct moisture is 4.1% (5.0%-0.9%)

Calculation of correct density:

Moisture 2 154 * 5.0% = 108
Wet density 2 154 + 108 = 2 262
Dry density 2 262 / (1 + 4.1%) = 2 173
Density 2 173 / 2 204 = 98.6%

6.4.3. VISUAL INSPECTION

The importance of visual inspections of the works cannot be overemphasised.

Acceptance control is achieved by doing spot checks, e.g., four densities over a 400m layer. The compaction effort is compared with the compaction effort that is done with the same material in the laboratory.

Isolated weak spots are not reflected in the test results and could only be seen by doing a visual inspection.

Common errors that could only be picked up with visual inspection include:

- Unstable wet spots caused by poor drainage or water truck leaking water on the layer
- Clay spots that are unstable
- Holes caused by dragging of stones when final cut was done
- Cement that is not spread evenly
- Laminations.

Example 6.5: MDD of sand

Example of test results LW134, LW186 and LW195. The MDD of the subgrade layer that varies, from 1 843kg/m^3 to 2 054kg/m^3. The subgrade is mostly sand, but in some areas larger stones are found in the layer, thus the higher MDD. Subgrade layers are compacted to 93% but if it is sand, it should be compacted to 100%. The question is: what specification should be used 93% or 100% for each patch?

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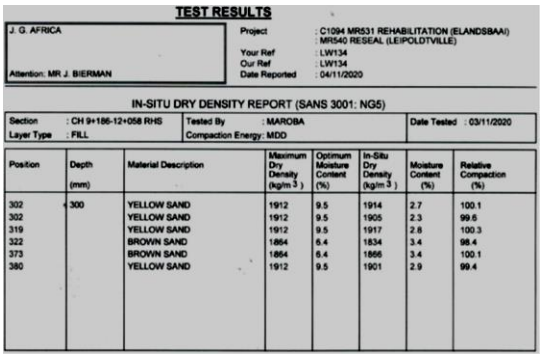
This could only be answered by looking at the subgrade of each patch. The best test to see if the sand was compacted properly is the visual heel test. Drag your heel on the compacted layer to see if it is loose or dense.



TEST RESULTS

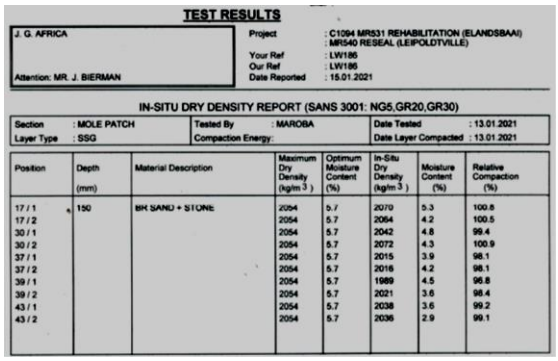
J. G. AFRICA
Attention: MR J. BIERMAN

Project : C1094 MR531 REHABILITATION (ELANDSBAAI) : MR540 RESEAL (LEIPOLDTVILLE)
Your Ref : LW134
Our Ref : LW134
Date Reported : 04/11/2020

IN-SITU DRY DENSITY REPORT (SANS 3001: NG5)

Section : CH 9+186-12+058 RHS | Tested By : MAROBA | Date Tested : 03/11/2020
Layer Type : FILL | Compaction Energy: MDD

Position	Depth (mm)	Material Description	Maximum Dry Density (kg/m 3)	Optimum Moisture Content (%)	In-Situ Dry Density (kg/m 3)	Moisture Content (%)	Relative Compaction (%)
302	300	YELLOW SAND	1912	9.5	1914	2.7	100.1
302		YELLOW SAND	1912	9.5	1905	2.3	99.6
319		YELLOW SAND	1912	9.5	1917	2.8	100.3
322		BROWN SAND	1864	6.4	1834	3.4	98.4
373		BROWN SAND	1864	6.4	1866	3.4	100.1
380		YELLOW SAND	1912	9.5	1901	2.9	99.4



TEST RESULTS

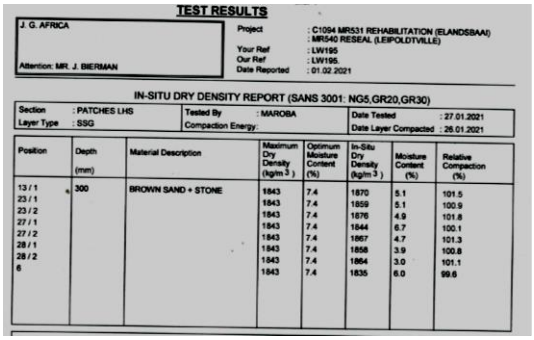
J. G. AFRICA
Attention: MR. J. BIERMAN

Project : C1094 MR531 REHABILITATION (ELANDSBAAI) : MR540 RESEAL (LEIPOLDTVILLE)
Your Ref : LW186
Our Ref : LW186
Date Reported : 15.01.2021

IN-SITU DRY DENSITY REPORT (SANS 3001: NG5,GR20,GR30)

Section : MOLE PATCH | Tested By : MAROBA | Date Tested : 13.01.2021
Layer Type : SSG | Compaction Energy: | Date Layer Compacted : 13.01.2021

Position	Depth (mm)	Material Description	Maximum Dry Density (kg/m 3)	Optimum Moisture Content (%)	In-Situ Dry Density (kg/m 3)	Moisture Content (%)	Relative Compaction (%)
17 / 1	150	BR SAND + STONE	2054	5.7	2070	5.3	100.8
17 / 2			2054	5.7	2064	4.2	100.5
30 / 1			2054	5.7	2042	4.8	99.4
30 / 2			2054	5.7	2072	4.3	100.9
37 / 1			2054	5.7	2015	3.9	98.1
37 / 2			2054	5.7	2016	4.2	98.1
39 / 1			2054	5.7	1989	4.5	96.8
39 / 2			2054	5.7	2021	3.6	98.4
43 / 1			2054	5.7	2038	3.6	99.2
43 / 2			2054	5.7	2036	2.9	99.1



TEST RESULTS

J. G. AFRICA
Attention: MR. J. BIERMAN

Project : C1094 MR531 REHABILITATION (ELANDSBAAI) : MR540 RESEAL (LEIPOLDTVILLE)
Your Ref : LW195
Our Ref : LW195.
Date Reported : 01.02.2021

IN-SITU DRY DENSITY REPORT (SANS 3001: NG5,GR20,GR30)

Section : PATCHES LHS | Tested By : MAROBA | Date Tested : 27.01.2021
Layer Type : SSG | Compaction Energy: | Date Layer Compacted : 26.01.2021

Position	Depth (mm)	Material Description	Maximum Dry Density (kg/m 3)	Optimum Moisture Content (%)	In-Situ Dry Density (kg/m 3)	Moisture Content (%)	Relative Compaction (%)
13 / 1	300	BROWN SAND + STONE	1843	7.4	1870	5.1	101.5
23 / 1			1843	7.4	1859	5.1	100.9
23 / 2			1843	7.4	1876	4.9	101.8
27 / 1			1843	7.4	1844	6.7	100.1
27 / 2			1843	7.4	1867	4.7	101.3
28 / 1			1843	7.4	1858	3.9	100.8
28 / 2			1843	7.4	1864	3.0	101.1
6			1843	7.4	1835	6.0	99.6

FIGURE 17: EXAMPLE OF TEST RESULTS LW134, LW186 AND LW195.

Note: The following must be checked on site, as there is no test that can be done afterwards to prove that the correct quantity was used.

1. Counting the bags of cement when stabilising
2. Taking dips on emulsion truck when doing BSMs
3. Taking dips on bitumen distributor when sealing.

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7. TRAFFIC ACCOMMODATION

The traffic accommodation is usually detailed on the drawings and described in the project document.

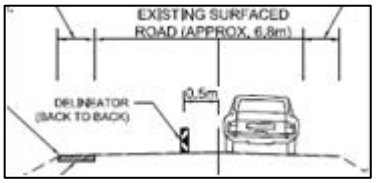


FIGURE 18: PHASE 1

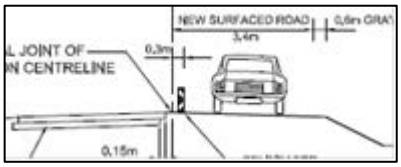


FIGURE 19: PHASE 2

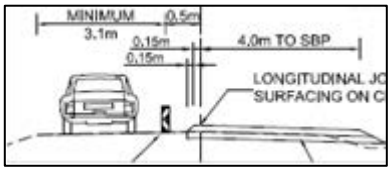
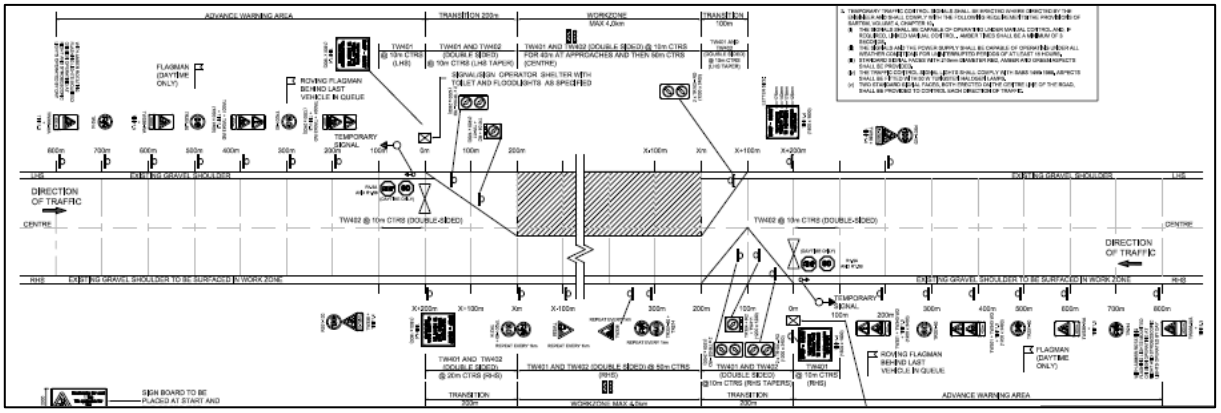


FIGURE 20: PHASE 3

Example of typical signage or half width traffic accommodation:



7.1. Traffic safety officer

A Traffic Safety Officer (TSO) needs to be appointed. This person will be responsible for all arrangements of traffic accommodation. A daily checklist of the condition and location of temporary road signs needs to be completed by the TSO. Example of checklist is shown in ***Appendix M***.

Important: This checklist is of critical value when an accident happens on site.

Warning: These records are used in court years later to determine if there was any negligence from the Engineer or the Contractor that may be the cause of death.

Tips:

- It is good practice to take a dashcam of the traffic signs on the road when an accident happens.
- Flagman diligence could mean the difference between life and death.
- Keep minimum sight distance 300m when approaching STOP/GO huts.
- Reduce speed by narrowing the width of the road.

A flagman that is alert and engages with the motorists earns respect and the public is usually co-operative.

Note: Clean and upright delineators make a good impression and gain respect from the public.

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Tip: The local traffic police should be contacted to help when motorists do not adhere to the speed limits in working areas.

Use *The South African Roads Traffic Signs Manual (SARTSM) volume 2 Chapter 13* as a guide for traffic accommodation that is not specified on the drawings, e.g., when temporary closures for line marking or shoulder obstructions are used.

7.2. Flagmen

Local labour is usually sourced for flagmen. Although they are only temporarily employed, they play a very important and prominent role regarding the safety of the project. Flagmen must be trained or formally shown what to do before exercising their duty.

Important: The safety of the workers and plant working on site is largely in the hands of the flagmen. It is their duty to make motorists aware of the construction activities and slow down their speed.

Tip: To establish a high standard for safety, warnings must be given, and contracts terminated within two weeks, for flagmen failing to do their duty properly.

Advice: Utilise good flagmen at dangerous areas, and make sure to replace lazy flagmen.

7.3. Payment

Projects with high traffic volumes normally have a clause for penalties for traffic accommodation, e.g., R5 000 per occurrence and R500 per hour since the instruction was given to rectify or replace signs etc.

In terms of payment, 50% of temporary deviations are paid for once constructed, and 50% are paid after the deviation road is removed.

Payment for 75% of the temporary road sign amount is made after erection and 25% after removal.

Danger: Flagmen are paid in man-days. Check the project document to see what the meaning is. Man-days could mean 8 hours, 9 hours, 12 hours, or 24 hours.

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Example of payment record for flagman:

Payment Item		Description	Unit	Rate	Quantity	Amount	
B15.03 a		Temporary traffic-control facilities Flagman	Man-day	R 1 081.64	500	R 540 820	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
…	…	Previous quantity brought forward			36,5	NK	JB
15/07/20	3	1 July – 6 July 2014					
		#60 shifts x 8 hours / 24 hours	3.4	20			
		#16 shifts x 9 hours / 24 hours	3.4	6			
		#24 shifts x 12 hours / 24 hours	3.4	12			
		Total		38	74,5	NK	JB

Note: It is useful to write a reference number on each invoice received, adopting a structured numbering convention, to provide backup documentation for future reference.

Example of Backup reference no. 3.4 for flagman:

Shifts			8 hours					9 hours				12 hours				**24h**
No.	Cert.	Date	Section 1	Access road	Section 2	Access road	**Total Shifts**	Recycle	Tipping	Concrete 1	**Total Shifts**	Forfar bridge	Pienaar's	Bronkhorstspruit	**Total Shifts**	**Total Man-days**
51	3	01-07-14					0	2		1	3		6		6	4.1
52	3	02-07-14	10	2			12	2		1	3		6		6	8.1
53	3	03-07-14	10	2			12	2	2	1	5		6		6	8.9
54	3	04-07-14	10	2			12	2	2	1	5		6		6	8.9
55	3	05-07-14	10	2			12				0				0	4.0
56	3	06-07-14	10	2			12				0				0	4.0
		Total					60				16				24	38.0

Note: Payment item B15.03 in the project document was specified for 24-hour man-day shifts.

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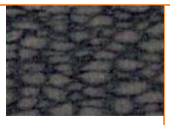
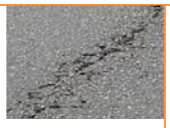
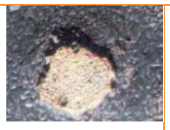
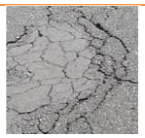
8. PATCHING

Repair of small road failures are called patching repair, e.g., < 100m^2, usually 1m^2 to 5m^2. These repairs are normally done before the construction of deviations.

Road failures should be marked out on the road with paint or spray paint. Each patch should be marked with a reference number and the type of repair, e.g., S (surface), B (base), D (deep, more than one pavement layer). A list of patches to be repaired should be given to the contractor via a site instruction. All referencing should be done using the patch number marked on the road.

The type of repair depends on the cause of the failure. Refer to *TMH 9: Manual for Visual Assessment of Road Pavements: Part B: Flexible Pavements*, for type of failures.

Important: The cause of the road failure needs to be addressed e.g., drainage.

Photo						
Distress	Minor cracks without deformation	Extensive cracking without deformation	Aggregate loss	Mechanical damage	Deformation	Wide ruts, undulations
Repair	Crack seal	Surface patch	Surface patch	Surface patch	Base patch	Subbase patch

Source: South African Pavement Engineering Manual, Chapter 14 Post Construction, Section 3 Distress, Table 3 Surfacing destress in flexible pavements, page 8, Table 4 Traffic associated destress in flexible pavements, page 10, Table 5 Environmentally induced distress in flexible pavements, page 11.

8.1. Combine Patching

After all the patches are marked on the road, the patches should be drawn on a layout plan. An Excel spreadsheet could be used to do this automatically.

It may be economical to combine patches or to rehabilitate larger areas that were marked for patching. Calculate the amount per patch and compare the cost of combining patches or rehabilitation of sections. Discuss this with the Site Agent. It may be beneficial for both the Client (bigger area repaired without bumps) and the Contractor (better production constructing larger areas).

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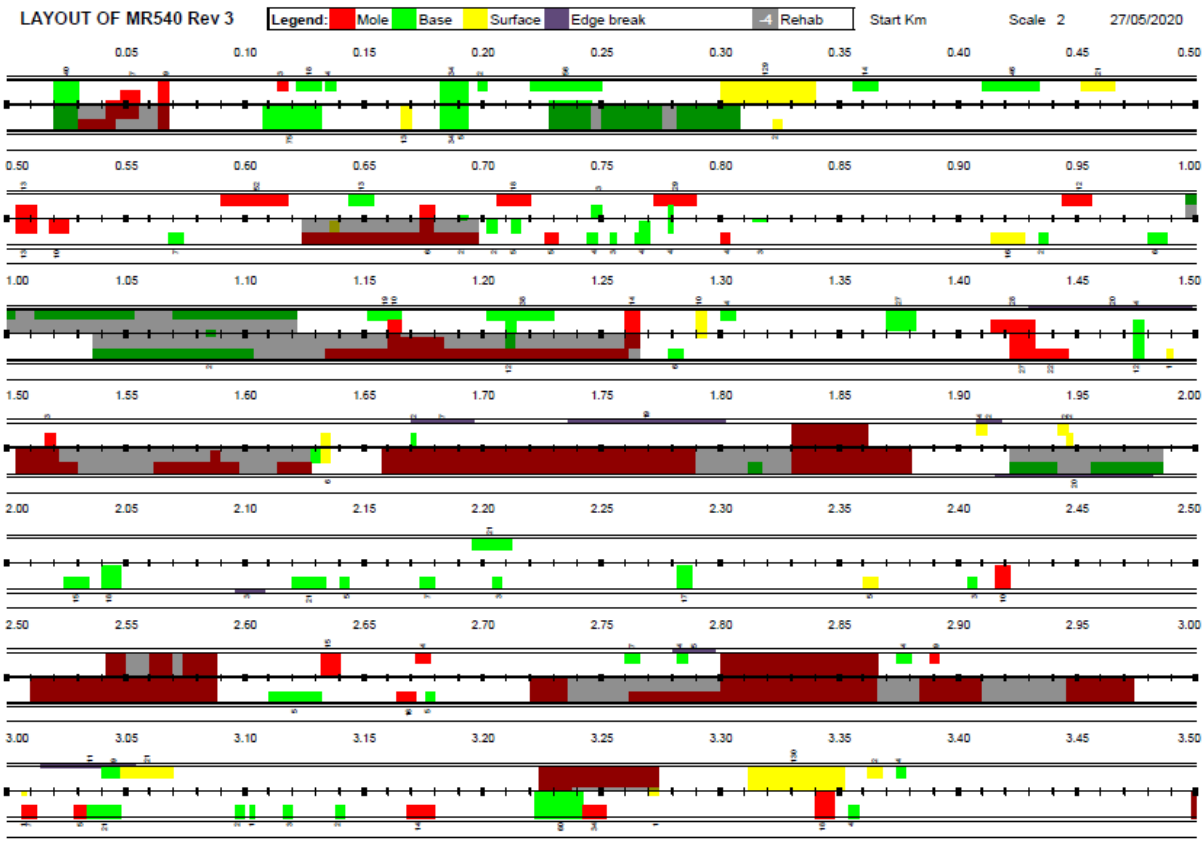
Example of cost comparison: Patch vs Rehabilitation:

Item	Description	Unit	Rate	Factor m2	Amount
Base Patch					
39.02(c)(i)	Excavate gravel/crushed stone base	m^3	R 225.83	0.16	R 36.13
39.03(b)(i)	Backfill ETB	m^3	R 1 435.23	0.16	R 229.64
39/42.04	Tack coat	litre	R 5.99	0.55	R 3.29
39/42.20(b)	Backfill asphalt	t	R 1 702.34	0.04x2.5	R 170.23
Total					**R 439.30**
Rehabilitation					
B34.04(f)(i)	In-situ reconstruction of subbase	m^3	R 64.45	0.2	R 12.89
35.02(g)	Cement	t	R 1 381.41	0.0066	R 9.12
B36.01(e)(i)	Crushed stone	m^3	R 724.86	0.15	R 108.73
Total					**R 130.74**

Base patch cost R439.30/R130.74 = 3.36 time more than rehabilitation.

Example of patching that was combined:



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Examples of backup sheet for payment item 39.03, date, stake value, or patch number:

Payment Item		Description	Unit	Rate	Quantity	Amount	
B39.03		Backfilling of excavations for patching with: (a) Chemically stabilised pavement material with 2% cement by mass compacted to 97% of maximum dry density for a patch with a surface area: (ii) Exceeding 5 m^2 but not exceeding 100 m^2	m^3	R 600.00	200	R 120 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	8	01/08/20 – 15/08/20 MR535 SV 0 – SV 1040	8.7	26.02	26.02	NK	JB
Or							
25/10/20	8	Patch no. 11, 16 – 18, 20, 30, 33, 43, 48, 60	8.7	26.02	26.02	NK	JB

Reference 8.7:

Patch no.	Date	SV	SV	Pos	Length	Width	Depth	Area	Volume
11	01/08/2020	181	191	RHS	10	3.4	0.15	34	5.1
16	02/08/2020	259.1	265.8	RHS	6.7	3.4	0.15	22.78	3.42
17	02/08/2020	269.7	272.7	RHS	3	3.4	0.15	10.2	1.53
18	03/08/2020	272.7	280.8	RHS	8.1	3.4	0.15	27.54	4.13
20	04/08/2020	300.8	311.3	RHS	10.5	3.5	0.15	36.75	5.51
30	05/08/2020	518.1	523.2	RHS	5.1	2	0.15	10.2	1.53
33	05/08/2020	567	571.5	RHS	4.5	1.5	0.15	6.75	1.01
43	05/08/2020	672.8	677.1	RHS	4.3	3.4	0.15	14.62	2.19
48	05/08/2020	706.2	709.8	RHS	3.6	1.5	0.15	5.4	0.81
60	05/08/2020	1035.5	1037.6	RHS	4	1.3	0.15	5.2	0.78
TOTAL:								**173**	**26.02**

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9. SERVICES & CULVERTS

9.1. Services

Existing services could obstruct or hinder the construction works. Positions of existing services should be confirmed and **clearly marked** to prevent any damage to these services.

A list of existing services is normally specified in the project documents or shown on the drawings. These positions are not always accurate.

Services include the following:

1. Sewer pipes
2. Water pipes
3. Telkom lines
4. Optic fibre, MTN, Vodacom, Neotel, etc.
5. Power lines, e.g., streetlights, houses, etc.
6. Eskom power cables

Warning: Damage to optic fibre is extremely costly and billed by the minute.

Tip: RE to stand next to the excavator/TLB when digging near an optic fibre/main water or sewer line to ensure that it is not damaged.

The project documents and/or the drawings will indicate a list of new services to be installed. These services are normally connected to existing services. Service ducts could be specified for future services to be installed, or for moving of current services. Details of ducts are shown in the drawings and/or the Bill of Quantities.

Note: Ensure that adequate ducts are placed at road crossings for future services, e.g., streetlights, traffic signals, optic fibre, etc.

Warning: Service ducts should be installed before the road subbase is constructed, to ensure the integrity of the pavement layers. Installing services after the subbase and base layer are constructed could cause the road to sag over that area, as the backfill of service excavations is done with light equipment, while compaction of subbase and base layers is done with heavy equipment.

Note: Dips in the base layer is often visible when service ducts are installed after the base layer is constructed and as the compaction effort and/or quality of backfill material is not the same as when the rest of the pavement layers were constructed.

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9.2. Wayleaves

Wayleaves need to be obtained from the relevant authorities to move, disconnect, or work near services. Wayleaves need to be obtained timeously to prevent any delays on the project.

Warning: It takes 15 to 20 days to obtain wayleaves from authorities.

Authorities issue work permits. They normally also issue drawings indicating where the services are located with x, y, and z coordinates.

NB: The locations, especially the levels, are not always accurate and need to be verified on site.

9.2.1. RAILWAYS

A work permit needs to be obtained to work near railway lines. All personnel working near railway lines need to be inducted. A safety officer is usually appointed to check that construction work is safely conducted.

9.2.2. ESKOM

Obtaining wayleaves and work permits from Eskom takes about six months. These negotiations should be done well in advance to prevent any delays on site. A contact person and contact details is usually given in the contract document.

During tender stage, a lump sum should be allocated for the moving or protecting of Eskom cables.

9.3. Location of services

The locations of services are not always accurate and need to be verified on site.

Tip: Look for manholes and boxes to locate and verify the position and level of existing services. Contacting the person who installed the service originally may be very helpful.

If services are not found, make use of cable detectors or other equipment, such as cameras, to locate services. Damage to an unknown service, like sewer, water, or power, affects the public and the community. Every possible measure should be taken to find and protect existing services. A specialist should be appointed as needed to help locate a service.

The levels of the service are not always accurate and must be verified on site. Services are normally placed 1,0m to 1,2m below the natural ground level.

This could mean that the design needs to be adjusted, as the tie-in levels differ from what is indicated on the drawings.

Advice: Minor sewer lines should be tied into the top level of existing main sewer lines. This could prevent temporary blocking of sewer lines for tie-in at a cost of R20 000 per day.

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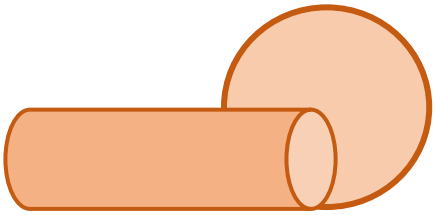

FIGURE 21: TIE-IN AT BOTTOM (INVERT) – STOP MAIN FLOW

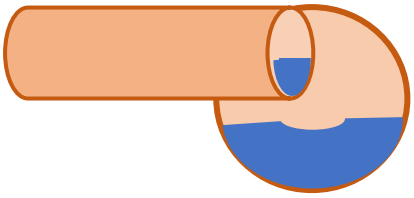

FIGURE 22:TIE IN AT TOP – NO STOPPING OF MAIN FLOW

9.4. Culvert Design

The size and location of pipes and culverts required on the road is calculated and shown on the drawings. Culverts are placed at low points; the exact locations must be confirmed on site. The level of the culverts should be double checked. The culvert inlet level must not be higher that the natural ground level.

Important: The cross section of any new culvert is to be drawn and compared to the edge levels to determine the length of culvert required at that location.

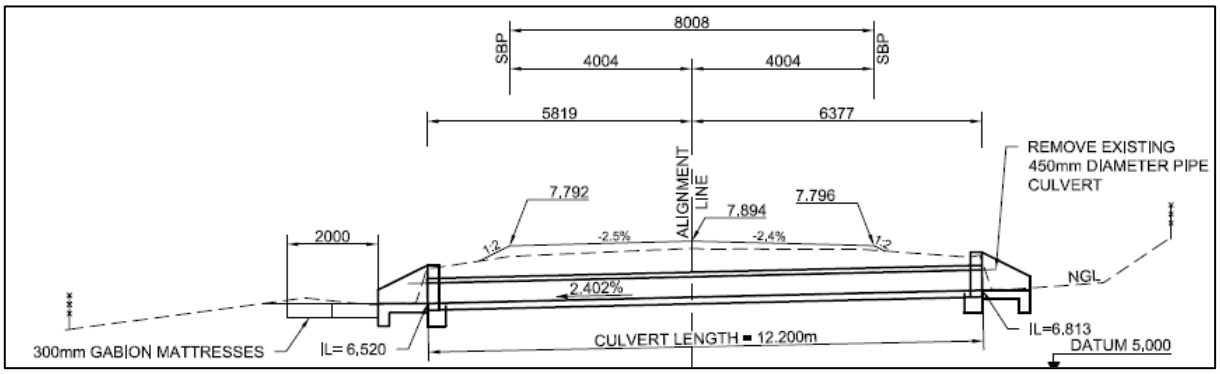

FIGURE 23: 1 X 900 X 450 PORTAL CULVERT AT SV 88122.83 SKEW 92.7˚

Pre-cast portal culverts are made in standard lengths of 1,22m and pipe culverts in 2,44m lengths. Avoid cutting of culverts, it is better to extend the culvert or build a slightly higher headwall at the inlet or outlet structure.

9.5. Materials

9.5.1. BEDDING

The bedding material should be sand or cohesionless material, all smaller than 6.7mm and no more than 10% passing a 0.15mm sieve.

The excavated material could be used by taking out the rocks and pebbles using a sieve. Imported material should be used if more than 20% of excavated material consists of pebbles. Hard rock and big stones are not to be used, as they could damage the pipe/duct.

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The bedding material should be the required thickness, especially when placed on a hard rock. The point load of the rock could damage the pipe/duct. Concrete encasement is sometimes specified in rocky areas to prevent point loads.

FIGURE 24: ROCK BEDDING

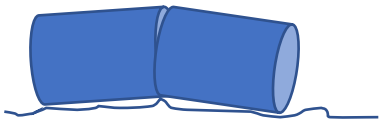

FIGURE 25: POINT LOAD ON ROCK

FIGURE 26: SAND BEDDING

The quality (CBR and PI) of mine fill should be tested before it is used for bedding or backfill material.

When in-situ material under the bedding material is unstable (heaving when walking over it), like marsh areas, a 200mm to 300mm pioneer layer should be placed before construction of the bedding.

The quality (CBR and PI) of mine fill should be tested before it is used for bedding or backfill material.

Source: *COTO Chapter 3: Drainage, Section 3.2: Culverts, page 3-18 to 3-38.*

9.5.2. SERVICE DUCTS & PIPE CULVERTS

Ensure that the right type of material is used for the specified service. The class of material is specified in either the Bill of Quantities and/or the project documents (scope of works) and/or the drawings.

Ensure the pipe/duct is the correct diameter, the inside diameter is usually specified as well as the strength of thickness of the pipe/duct.

The class of pipe/duct and the SABS marks should appear on the product. If there is no mark or SABS mark, then the material is not correct and should be rejected. Pitch fibre pipes are easily deformed and no longer used. The class (50D, 75D, or 100D) indicates the thickness of stormwater pipe culverts. Many times, pipes are damaged during the loading and off-loading of the pipes on site.

Examples for pipes:

FIGURE 27: PVC CLASS 6 PIPE

FIGURE 28: PITCH FIBRE PIPE

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9.5.3. PORTAL CULVERTS

Portal culvert sizes are the width and the height of the culvert, e.g., 900mm x 450mm (W x H). The class culvert e.g., S175 indicates the thickness of the culvert.

Big portal culverts higher than 0.5m are easily damaged when not correctly off loaded. A crack will be visible in the upper corner of the culvert. Any damaged portal culverts must be rejected and replaced. Minor damage at the toe can be repaired.

FIGURE 29: PORTAL CULVERTS, MINOR DAMAGE TO TOE REPAIRED

9.6. Method Statements

The Contractor must submit a method statement for installing services and culverts on site before the work is undertaken.

The following aspects must be covered in the method statement for services:

1. Wayleave application
2. Safety requirements when working near power lines
3. Time period for services to be completed
4. Minimising the effect of lack of services to be public.

The following aspects must be covered in the method statement for services and culverts:

1. Delivery and location of stacking culverts
2. Shoring or deep excavations
3. Protection of excavations
4. Level control
5. Start installing at downstream side
6. Hold point: approval of bedding material and density
7. Hold points for alignment of culverts
8. Equipment used for backfilling; plate compactors is not effective
9. Maximum thickness of compacting backfilling, whackers/jolly jumpers can only compact effectively 100mm thick layers
10. Measures to prevent floating of culverts during rainy seasons or when concrete encased
11. Testing of backfilling.

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Equipment and estimate compaction depth:

FIGURE 30: PLATE COMPACTOR, 20MM

FIGURE 31: WHACKER, 50MM – 100MM

FIGURE 32: HAND GUIDED VIBRATORY ROLLER, 150MM

The safety of excavations must be thoroughly discussed. Excavations during the rainy season can become unstable.

FIGURE 33: EXAMPLES OF EXCAVATION

9.7. Checklist

The most important check for culverts is the most logical one:

Important: Culvert is to be placed at the correct location, low point.

Looking at the natural ground level, is the culvert placed at the low spot? If not, inform the Engineer and move the culvert to the low point, it might be just 10m away. Ensure that the culvert is placed in line of the water flow. Do not change the direction of the flow!

The following main points should be checked when installing services and culverts:

1. Is the pipe the right diameter?
2. Is the pipe thickness correct?
3. Is the pipe type correct?
4. Is the pipe cracked, or severely chipped?
5. Is the depth and level of the excavation correct?
6. Is temporary shoring adequate?
7. Is there any rock or unsuitable material that should be replaced?
8. Half width instalment, is the traffic end properly supported?
9. Do all joints fit tightly?
10. Is backfilling done in 150mm layers, both sides simultaneously?

Refer to *Appendix J3 (Services)* and *Appendix J5 (Culverts)* for complete checklists.

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9.8. Progress

Completion of the worksheet is not really necessary, but it may be done for monitoring the progress only. A personal diary could also be kept instead of completing the worksheet. Any delays, such as later delivery of material, hard rock, lack or breakdown of plant, should be recorded or diarised.

See Appendix K2 for example of a worksheet.

9.9. Inspection and Tests

9.9.1. BEDDING

The contractor must submit an inspection request after excavation and preparation of the bedding. The density of the bedding must be tested and approved before the culvert could be placed. Grading of the bedding material needs to be tested and approved. A sandy material is preferable. Normally, three density tests are done on the bedding material.

9.9.2. ALIGNMENT

The constructor must submit an inspection request to check and approve the alignment and joints of the culvert before backfilling can be done.

9.9.3. BACKFILL

The contractor must submit an inspection for the testing of the backfilling of the culvert. The density of the bedding, as well as the density of the backfilling of the culvert, need to be tested. Backfilling could be tested in 300mm layers.

Optimum moisture must be checked by hand. Press a handful of soil/sand together. Open your hand: if the gravel/sand falls apart, it is too dry; if it stays in a ball, the moisture is good. Gravel/sand that is too wet will heave under the rollers.

FIGURE 34: MOISTURE TOO DRY

FIGURE 35: GOOD MOISTURE

FIGURE 36: MATERIAL TOO WET

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9.9.4. SECURITY

Power lines, and even plastic pipes, are often stolen after installation when working in townships. Provision should be made to provide security to ensure that the service is not stolen during installation.

It is advisable to speak to the community leaders in this regard. Explain that the service will benefit the community and that it is their own interest to ensure that the service is not stolen before it is properly backfilled.

9.10. Evaluation

The density of the bedding and the density of the backfilling need to be equal to or higher than the specified density. Sand should be compacted to 100% of modified AASHTO density while gravel material is normally to 93% of modified AASHTO density.

Refer to the typical drawings and COLTO for grading and compaction required on the bedding material.

The staff member responsible for supervision of the layer signs off and comments on the visuals, materials, and levels of the layer.

See Appendix B3 for a register and Appendix E3 for an inspection request template.

The following forms are signed off and form part of the package that is stapled together:

1. Test request from Contractor
2. Random positions and tests to be done issued to the laboratory manager
3. Laboratory test results submitted by the laboratory manager
4. Levels submitted by the surveyor or dips taken by the foreman
5. Checklist of supervision staff
6. Statistical analysis of test results
7. Final comment on test request by Resident Engineer
8. Sign off inspection request register.

The Resident Engineer makes a final decision and will write one of the following comments:

- Accepted
- Rejected
- Reduce payment
- Re-test
- Remedial actions required
- Monitor.

The layer can now be paid according to findings of the Resident Engineer.

9.11. Payment

Warning: The contractor cannot be held responsible for damaging a service that was not identified when the site was handed over. It is thus of utmost importance that all services are located before construction starts, especially optic fibre. An internet search should be

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conducted, and all optic fibre suppliers be contacted to ensure that the position of optic fibre is located.

Note: Verifying the positions of existing services forms part of the contractor's general obligations, *refer to COLTO 1202,* and forms part of payment item 13.01, *refer to COLTO 1302 c ii*, unless provided for in the Bill of Quantities. Payment items for services provided are specified in the BoQ section 1200 and 2200.

Excavation width is normally paid with a working space around the culvert of 0,5m on each side (COLTO). Refer to the drawings to check if working space is specified.

Different rates apply for excavation over 1,5m and 3,0m. Benching is required and/or other equipment like an excavator instead of a TLB may be required to excavated deeper than 1,5m.

Hard material for excavation is classified as the following (COLTO 2105/2208):

1. Material which cannot be excavated except by drilling and blasting or with the use of pneumatic tools or mechanical breakers
2. Boulders exceeding 0.10m^3
3. More than 40% of any material (by volume) consisting of boulders each exceeding 0.10m^3.

Note: Payment is done according to the drawings; no extra payment is made if the excavation was made wider or deeper.

Example of measurement and payment record:

Payment Item		Description	Unit	Rate	Quantity	Amount	
22.01		Excavation a) Excavation soft material situated in the following depth ranges. I) 0m up to 1.5m	m^3	165	200	R	33 000
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
27/10/20	*10*	*Km 80.010*	*10.1*	*30.24*			
		Km 80.25	*10.1*	*30.13*			
		Km 80.50	*10.1*	*34.76*			
		Km 82.440	*10.1*	*25.00*			
		Km 89.92	*10.1*	*35.58*			
		Total		*155.718*	*155.718*	NK	JB

Payment Item		Description	Unit	Rate	Quantity	Amount	
22.03		Concrete pipe culverts: c) On class C bedding ii) 600mm diameter ogee type (Class 75D)	M	R 1 220.00	50	R	61 000
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
1/7/20	*6*	*Km 77,42 R: 2 x 2,44 #2*		*9.76*			
		Km 88,35 R: 2 x 2,44		*4.88*			
		Total		*14.64*	*14.64*	NK	JB

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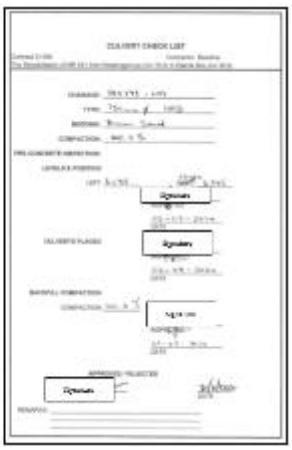
Example of package to be signed off:

Bedding inspection: Inspection request & approval, checklist, lab results and evaluation:

Alignment inspection: Inspection request & acceptance, progress summary, checklist:



Backfill inspection: Inspection request & acceptance, lab test & evaluation layer 1, 2 &3:

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Example of Excel spreadsheet used to calculate quantities of service ducts:

		Pipes in Ducts													
From SV	No of Pipes	110 Dia	160 Dia	250 Dia	310 Dia	Duct Area	Excavation Depth	Excavation Width	Excavation Length	Excavation Volume (0.0 1.5m)	Excavation Volume (1.5 3m)	Soilcrete Length	Beckfill Volume Soilcrete	Beckfill Voume (Excavated Material)	Duct Length
80010	2		1		1	0.096	1.35	1.55	14.50	30.24	0.00	5.40	10.75	18.16	14
80250	2		1		1	0.096	1.30	1.55	15.00	30.13	0.00	5.40	10.33	18.36	15
80500	2		1		1	0.096	1.60	1.55	15.00	34.76	2.32	5.40	12.83	22.81	15
82440	2	1	1			0.030	1.30	1.35	14.30	25.00	0.00	5.40	9.28	15.34	13
89920	2	1			1	0.085	1.40	1.50	17.00	35.58	0.00	5.40	10.84	23.29	17
										155.718	2.318	27.000	54.035	97.966	

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10. DRAINAGE

It is no use to repair a road and not address the cause of the problem. As the saying goes, there are three main causes of road failure: water, water, and water. It is critical to ensure that roads are adequately drained.

Underground water, fountains and areas with high water tables are known beforehand or discovered during excavations for bridge footings or pavement layers.

FIGURE 37: HERRING BONE DRAIN

These areas are effectively drained using one of the following methods:

- Drainage blanket
- Subsoil drains
- Herring bones (subsoil drains pattern)

Wet areas should be dried out by excavating a sump at the low point and pumping water out to investigate the extent and source of the problem.

10.1. Open Drains

It is important that water drains off the road into the veld (fill area) or into an open drain (cut areas). Open drains prevent water from crossing the road. Open drains should be deep enough, at least the depth of the pavement layers, normally 0.5m deep.

Open drains could be V-shaped drains, or trapezoidal shaped drains.

Warning: Open drains on steep gradients should be constructed with a mitre drain to prevent erosion. If mitre drains cannot be constructed, energy dissipators are required in the open drain.

10.1.1. MEASUREMENT AND PAYMENT

Quantities to construct open drains are determined using cross sections. If cross sections could not be used, quantities are paid using tally sheets.

Note: Tallies refers to keeping a tally sheet recording the time of arrival, registration number, and cubic metres delivered by each truck.

Random checks should be done if excavations are paid according to the number of trucks that were loaded. To determine the number of trucks, it is advisable to determine how long it takes for a truck to load and offload. This will indicate the maximum loads per day. Payment is made on 70% of the loose density material on the truck, e.g., $10m^3$ truck x 0.7 = $7m^3$.

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10.2. Concrete Lined Drains

Concrete lined drains are normally constructed in rock cuttings or at access roads (concrete drifts). Concrete drifts must not be too steep. Guide for concrete drift is 1:10 slope over 2m panel.

10.2.1. CHECKLIST

The main points to be checked when casting concrete lined drains are:

1. Is the distance from the centre line correct?
2. Is the excavation clean and compacted, no loose material?
3. Is the shutter at the back rigid, and straight?
4. Are there expansion joints at 10m intervals?
5. Are cover blocks used at the bottom?
6. Is the correct type of mesh used?

FIGURE 38: MESH IN CONCRETE SIDE DRAINS

For a complete checklist see ***Appendix J1***.

Warning: Emulsion stains on concrete cannot be removed and concrete needs to be replaced.

Important: The level of the concrete side drain should be lower than the surfacing to ensure that the water will drain off the road into the concrete lined drain.

10.3. Subsoil Drains

Pore water pressures caused by the available head in the adjacent cut or from the adjacent uphill road may lead to pavement distress. Provision for subsurface drainage is made in the road foundation in cuttings.

The provision of permanent subsoil drains below the surface or next to the pavement layers in cuttings normally also goes hand in hand with the provision of lined side drain surface drainage systems next to the paved road, in conjunction with sealed shoulders.

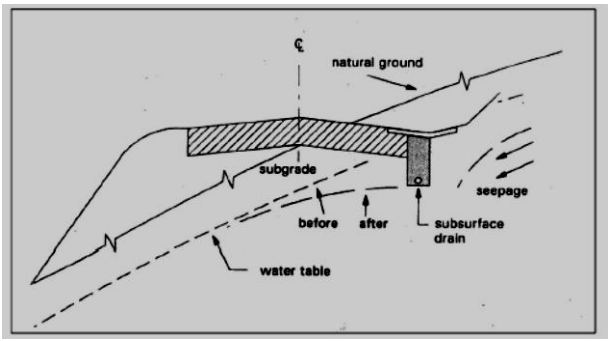

FIGURE 39: INTERCEPTOR DRAIN (FROM TRH15, 1994)

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10.3.1. CHECKLIST

The main points to check when constructing subsoil drains are:

1. Is the correct sand/aggregate used?
2. Is the stone clean and not contaminated? (NB!)
3. Cleaning eyes should be installed at 50m intervals.
4. Was a flush test done?

For a complete checklist see ***Appendix J2***.

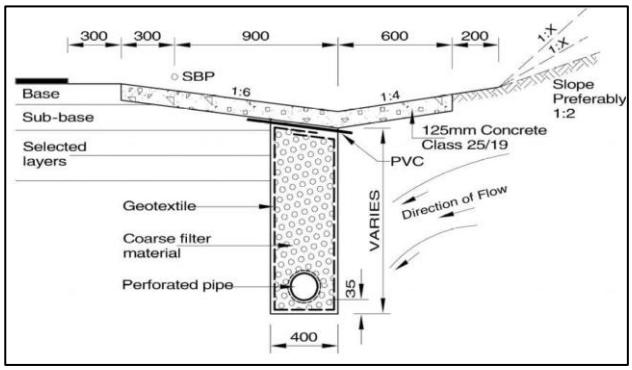

FIGURE 40: TYPICAL SUB-SURFACE INTERCEPTION GEOCOMPOSITE DRAIN DETAIL

Source: *SANRAL Drainage Manual, 6th edition, Section 12.3.3: Design capacity of intercept drains, Figure 12.2: Typical sub-surface drain details, page 12-6.*

10.4. Drainage Blanket

A drainage blanket is constructed when springs are present under the road. These blankets consist of single size aggregate or sand to drain the water. Subsoil drains are required in cuttings to drain the water from the blanket.

Subsoils under the road could also be constructed in a herring bone shape to drain the water from underneath the pavement layers.

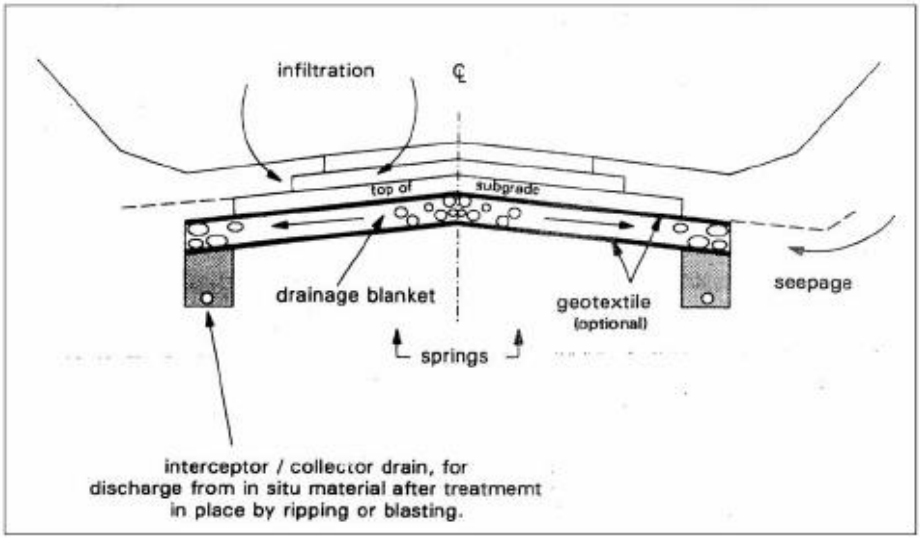

FIGURE 41: DRAINAGE BLANKET (FROM TRH15, 1994)

candidate® academy
the road to registration – tower above the rest
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10.5. Kerbs and Down Chutes

Kerbs and down chutes are normally placed on high fills on bridge crossings with guardrails.

The main points to check for the construction of kerbs and channels are:

1. Is the correct type of kerbs used?
2. Is the distance from the centre line correct?
3. Is the down chute or transition in the correct place?
4. Is kerb face damaged?
5. Are all concrete spills removed and painted with emulsion?
6. Are the kerbs in a straight horizontal line?
7. Is the height of the kerb correct and in a vertical straight line?
8. Does the water flow in the channel?

For a complete checklist see ***Appendix J4***.

10.6. Payment

Example of payment item 23.08, concrete lining for open drains:

Payment Item		Description	Unit	Rate	Quantity	Amount	
23.08		Concrete lining for open drains (a) Cast in situ concrete lining (class 19/20)	m^3	R 1 200	500	R 60 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	5	Km 83.0 – km 83.44 LHS	5.9	116.3			
		Km 83.0 – km 83.44 LHS	5.9	115.6			
		Km 83.0 – km 83.44 LHS	5.9	76.9			
		Total		308.8	308.8	MK	JB

Backup reference 5.9 for concrete drains:

km Start	km End	POS	Length	Thick	Width	Excavate	Mesh 395	Concrete	U2	F2
83.00	83.44	LHS	442.5	0.10	2.5	183	4356	116.3	1147	44
83.72	84.16	LHS	440	0.10	2.5	181	4331	115.6	1141	44
84.51	84.80	LHS	292.5	0.10	2.5	121	2879	76.9	758	29
Total			1175			484	11566	308.8	3045	118

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11. CONCRETE

The contractor will set up his own concrete batch plant if there is a large quantity of concrete work on site and no commercial supply available in the area. Small concrete quantities are normally mixed on site with a small concrete mixer that could be easily transported.

11.1. Designs

The concrete mix design must be submitted by the Contractor and approved by the Engineer. Concrete designs, from well-known commercial sources, is not a real concern. Attention must be given to special types of concrete, e.g., high durability concrete, rapid curing concrete, self-compacting concrete.

Helpful resources: *Fulton's Concrete Technology, Portland Cement Institute, Concrete Manufacturers Association.*

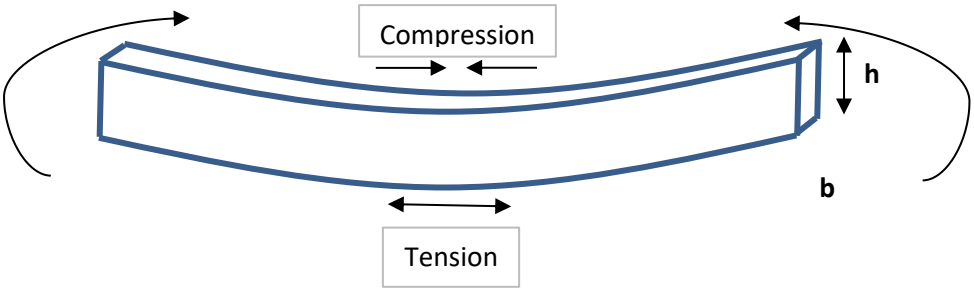
Key point: The cement content is normally specified for durability concrete.

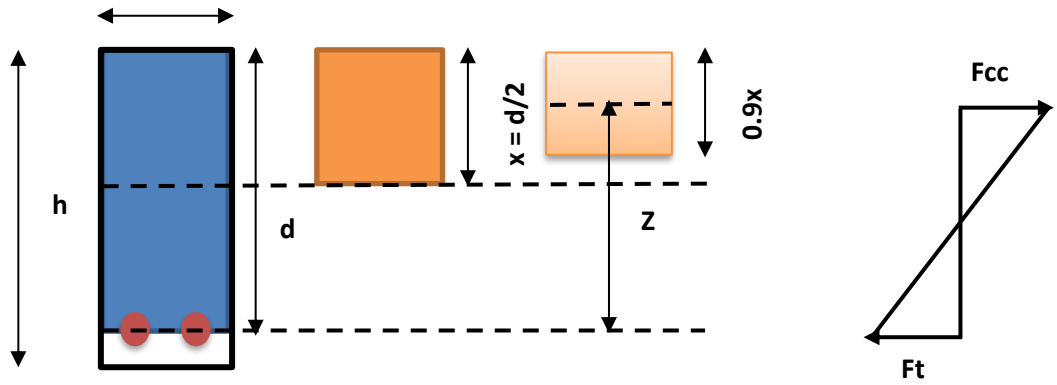
Mix designs used in remote areas or small quantities mixed by hand need investigation.

Danger: Alkali aggregate reaction should be checked.

11.1.1. DESIGN OF REINFORCED CONCRETE

Stress = Force / areas $\sigma = F/A$
Stress is either compression or tension
Reinforced concrete: Steel contributes to tension





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Concrete	Reinforcing
Compression strength	Tension strength
Class 25/19: 25MPa	High yield steel (Y): 450MPa
Weight = 2 400kg/m³	Weight = 7 800kg/m³
Safety factor: 1.5 Construction factor: 0.67	Safety factor: 1.15
Area: 90% of 'top' area: 0.9*x*b; x = d/2	Areas (As): πr² (area steel)
F = σ*area	F = σ*area
Fcc = (0.67*fcu/1.5)*(0.9*x*b)	Ft = (fy/1.15)*As

Momentum = Force x distance

Moment compression = Fcc*Z	Momentum tension = Ft*Z
Area = 0.9*x*b = 0.9*d/2*b = 0.45*b*d	Area = As
Z = d – 0.45*C = d – 0.45*(d/2) = 0.775*d	
Force = σ*area	Force = σ*area
Fcc = 0.67*fcu /1.5*0.45*b*d	Ft = (fy/1.15)*As
Moment compression = 0.67*fcu/1.5*0.45*b*d*0.775*d	Moment tension = 0.87*fy*As*Z
= 0.156*fcu*b*d²	

Important: Distance Z is very important!

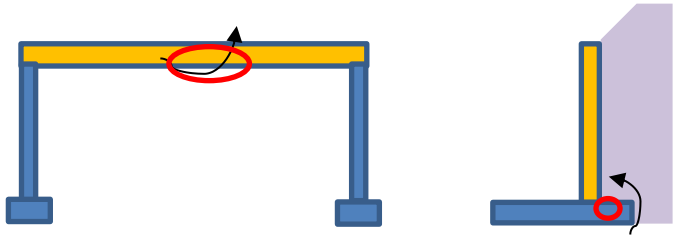

FIGURE 42: EXAMPLES OF MAXIMUM TENSION

Warning: Reinforcing cover and concrete honey combing are critical at locations of maximum tension!

11.1.2. MESH CALCULATIONS

Mesh reference is given in kg/m^2, e.g., mesh ref 395 is 3.95kg/m^2.

Example of mesh calculation

What is the mesh reference for Y8 bars spaced at 200mm centre to centre (c/c)?

Number of Y8 bars in 1m^2 is: 1m/0.2m = #5 bars in each direction, thus total #10 bars in both directions.

Area of Y8 bars: πr^2 = 22/7 x 0.004^2 = 0.0000503m^2

Steel is 7 850kg/m^3

Weight of mesh per square meter: #10 bars x 0.0000503m^2 x 7 850km/m^3 = 3.95kg/m^2.

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11.1.3. REINFORCING CALCULATIONS

Mild steel is 250MPa Heigh tensile steel is 450MPa

Important: Reinforcing may not be welded as it changes the strength of the steel.

Overlap length of steel is normally specified on the drawings and is usually 40 – 50 times the diameter.

Example of lap length

Specified lap length on drawings is 40 x diameter.
Reinforcing lap length for Y12 is thus 40 x 12mm = 480mm.

Example of reinforcing strength

Is the R16 bar stronger than the Y12 bar?
R16: Force = $\sigma A = \sigma \pi r^2$ = 250MPa x 22/7 x 0.008mm x 0.008mm = 0.050N
Y12: Force = $\sigma A = \sigma \pi r^2$ = 450MPa x 22/7 x 0.006mm x 0.006mm = 0.051N
Thus, a R16 is not stronger than a Y12 bar.

11.2. Materials

11.2.1. CEMENT

The old SABS 471 specification is replaced by the SANS 50197-1 specification for common cements and SANS 50413-1:2004 for masonry cements.

11.2.2. AGGREGATE

Refer to *COLTO 6402 b* for properties of concrete aggregate.

11.2.3. WATER

Water shall be clean and free from any detrimental concentrations of acids, alkalis, salts, sugar, or other organic material that could impair the durability and strength of the concrete or imbedded steel.

Chlorite content of mixing water for prestressed and reinforced concrete shall not exceed 500mg/ℓ.

Maximum inorganic impurities allowed in water COLTO Table 8116/1:

Characteristic	Criteria
pH	4.5 – 8.5
Sulphates	Reinforced and prestressed concrete: 400 ppm Mass concrete 1 000 ppm
Chlorites	500 ppm
Conductivity @ 25°C	330 mS/m
Total dissolved solids (TDS) @ 180°C	Mass concrete 3 000 ppm Reinforced concrete 1 500 ppm
Alkali carbonates and bicarbonates	1 000 ppm
Sugar	Negative
Organic impurities	300 ppm (applicable in pH < 6)

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11.2.4. ADMIXTURES

Refer to *COLTO 6402 e* for specifications on concrete admixtures.

11.2.5. CURING AGENTS

Curing agents shall comply with ASTM C309, except that the loss of water within 72 hours shall not exceed 0.40 kg/m^3.

11.3. Method Statements

The Contractor must submit a method statement for casting concrete. Method statements may differ considerably, depending on the type of concrete and structure. Environment and weather condition must be considered. Refer to standard specification and special specifications in the project document.

The following general issues need to be addressed in all method statements:

1. Access to the site/structure
2. Mixing equipment suitable for applications
3. Amount of extra water that can be added to the design mix
4. The use of additives e.g., retarders when hauling long distances
5. Type of cover block that will be used
6. Curing compound to be used
7. Pre-concrete inspection is a hold point
8. Use of tie rods and repair of funnels
9. Repair of honey combing.

Specific issues to be addressed in the method statement may include the following:

1. Dewatering/caissons
2. Risks working during the rainy season
3. Heating of water when working in cold weather
4. Cooling of aggregate/night work when working in hot weather
5. Rate of concrete delivery for pump mixes
6. Segregation of concrete when using a long chute.

Important: A dedicated person should check leakages under the bridge and movement/stability of false work while casting concrete.

11.4. Checklist

A pre-concrete inspection or formwork and reinforcement checklist is completed before the concrete inspection checklist. This is a hold point.

Important: No concrete should be ordered or mixed before the pre-concrete checklist has been completed and signed off.

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11.4.1. PRE-CONCRETE CHECKLIST

The following main points should be checked before ordering or mixing concrete:

1. Is the position and level of structure correct? Survey check.
2. Are there any openings where concrete can leak out?
3. Is the formwork properly braced, so that it will not 'kick'?
4. Is the cover between bars and the side of formwork correct?
5. Is the bottom and top cover correct?
6. Are all the reinforcement bars there?

For a complete checklist see ***Appendix J6***.

All the reinforcement should be checked by marking off the bars in the bending schedule.

Explanation of bar code 111 Y20 05 175 B1 STG:

1. 111 number of bars
2. Y20 R or Y (mild or tensile steel) and diameter of bar
3. 05 bar mark
4. 175 spacing of bars
5. B1 position of bar, e.g., bottom 1
6. STG placing of bar, e.g., staggered, alternate, etc.

Important: The splicing length of bars will be indicated on the drawings. It is normally 40 x diameter.

11.4.2. CONCRETE CHECKLIST

The following main points should be checked when casting concrete:

1. Is the correct class of concrete used?
2. Is the concrete vibrated with pokers?
3. Is the inside surface clean?
4. Is construction joint clean, hard and with a rough surface?
5. Is construction joint saturated with water and dried/damp?
6. Is concrete being cured?

For a complete checklist see ***Appendix J7***.

FIGURE 43: BREAK BACK CONSTRUCTION JOINT

11.4.3. POST-CONCRETE CHECKLIST

The following main points should be checked after the shutters have been stripped:

1. Are there any major defects?
2. Are the horizontal levels correct?
3. Are the vertical levels correct?
4. Is the concrete cover to reinforcing acceptable?

For a complete checklist see ***Appendix J8***.

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Definition: Surface finish

- F1: As stripped finish required for concealed formed faces e.g., underground.
- F2: Wood shutter, minor surface blemish and slight discolorations, visual exposure.
- F3: Steel shutter, surface rubbed and treated to form smooth finish of uniform texture, appearance and colour.

Source: *COTO Chapter 13: Structures, Section 13.2: Falsework, Formwork and Surface Finish, Part A13.2.7.2.b) Formed surfaces: Classes of finish, page 3-27*

11.5. Worksheet

A Worksheet needs to be completed and signed by both the Consultant and the Contractor. ***See Appendix K1 for an example.***

Important: It is important to record when the concrete trucks arrive on site and when concrete was poured and in what sequence the concrete was poured, especially if a batch of concrete failed.

11.6. Tests

The slump of the concrete is tested, and cubes are taken for 28-day compressive strength.

11.6.1. SLUMP

Slump tests are done before the concrete is cast. The slump is an indication of the workability of the concrete. If the slump is too low, the concrete could not be properly discharged and/or vibrated. The slump is also an indication of the strength of the concrete. If the slump is too high, the concrete will not reach the required strength. This is not applicable when admixtures are used in the concrete.

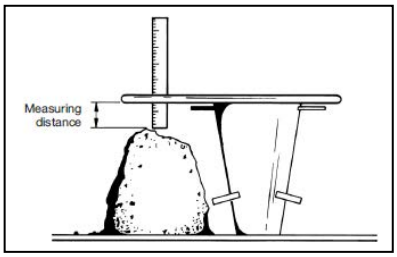

FIGURE 44: SLUMP TEST

Important: It is very important to discuss **beforehand** what the acceptable slump is for the concrete to be used, and what the procedure is when the slump is either too high or too low.

There is a high risk that the concrete with a high slump will be rejected after 28 days. The Resident Engineer must decide what the implications are for rejecting concrete on an important concrete structure vs the margin of accepting a high slump on concrete without admixtures.

Note: Concrete with high slump could be used when admixtures are used, refer to the supplier for more information.

11.6.2. COMPRESSIVE STRENGTH

The compressive strength of concrete is tested after 28 days. A minimum of four concrete cubes should be taken for statistical analysis. Samples are to be covered with plastic if not transported to the laboratory. Samples are to be placed on a rubber mat in the bakkie when transported the same day.

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Additional cubes are taken to be broken after seven days to give an indication of the 28-day test result; normally two thirds of compressive strength are obtained after seven days.

11.6.3. OTHER TESTS

The non-destructive concrete test could be done with a Schmidt Hammer: although it is not accurate, weak spots could be identified.

Destructive tests, like coring of structures, can be done to prove whether the concrete compressive strength was achieved.

A cover-meter is used to measure the cover of the concrete around the reinforcing.

11.7. Evaluation

The average concrete compressive strength should be greater than the acceptance limit when using statistical analysis, x_n > La. Refer to ***Chapter 6.3*** for statistical analysis. Rejection limit is 0.85 x La, but it is subject to the engineer's decision.

Source: *Table A20.1.7-9: Values of Constants n, L_s, L'_s, AND ø, COTO Chapter 20: Quality Assurance, Section 20.1: Testing Materials and Judgement of Workmanship, Part A20.1.7.5: Assessment Methods, page 20-47.*

If there is any doubt that a certain portion of a structure has a weak spot, or that repair of honey combing was not done correctly, the Schmidt hammer test or coring could be done. Coring is normally only done on structural concrete.

See ***Appendix B2*** for a register and ***Appendix E2*** for an inspection request template.

11.8. Payment

Payment is done according to the dimensions shown on the drawings.

Payment should be withheld if there is reason to believe that the 28-day compressive strength will not be met based on the seven-day cube results.

Payment Item		Description	Unit	Rate	Quantity	Amount	
22.07 c		Cast in situ concrete and formwork, Inlet and outlet structures, Class 30/19 concrete	m^3	R 2 600	10	R 26 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/11/20	2	Culvert km 5,73 LHS inlet	2.3	1,5	4,2		

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12. EARTHWORKS

Road earthworks consist of pavement layers and mass earthworks called cut and fill. A new road is designed to balance the cut and fill quantities, e.g., cut material = fill material.

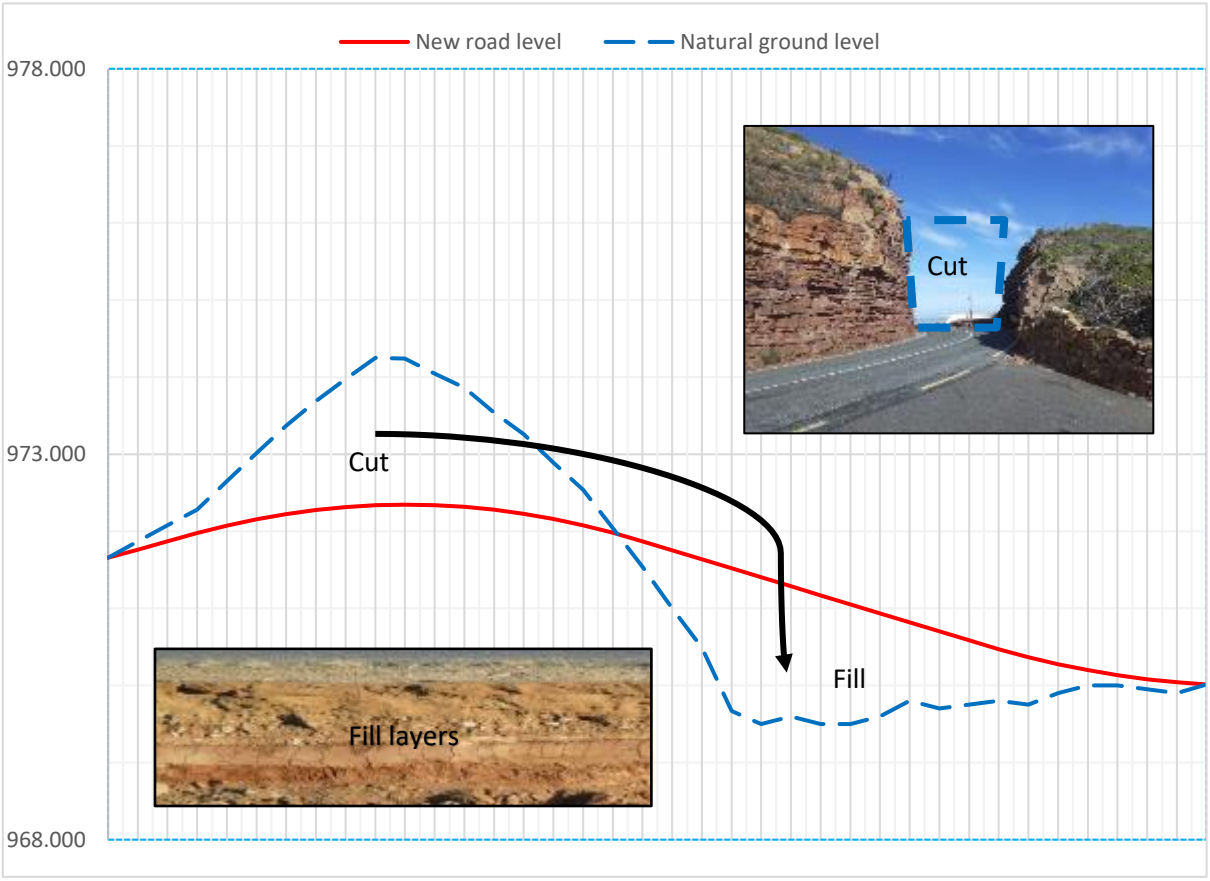

FIGURE 45: LONG SECTION: CUT AND FILL PROFILE

The thickness of the pavement layers over the fill layer is fixed. The thickness of the fill layer varies. The higher the pavement layers are above the natural ground level, the thicker the fill is. If the bottom of the pavement layers is below the natural ground level, the road is in a cut. The existing material is excavated. The in-situ layer constructed is called the roadbed.

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12.1. Roadbed

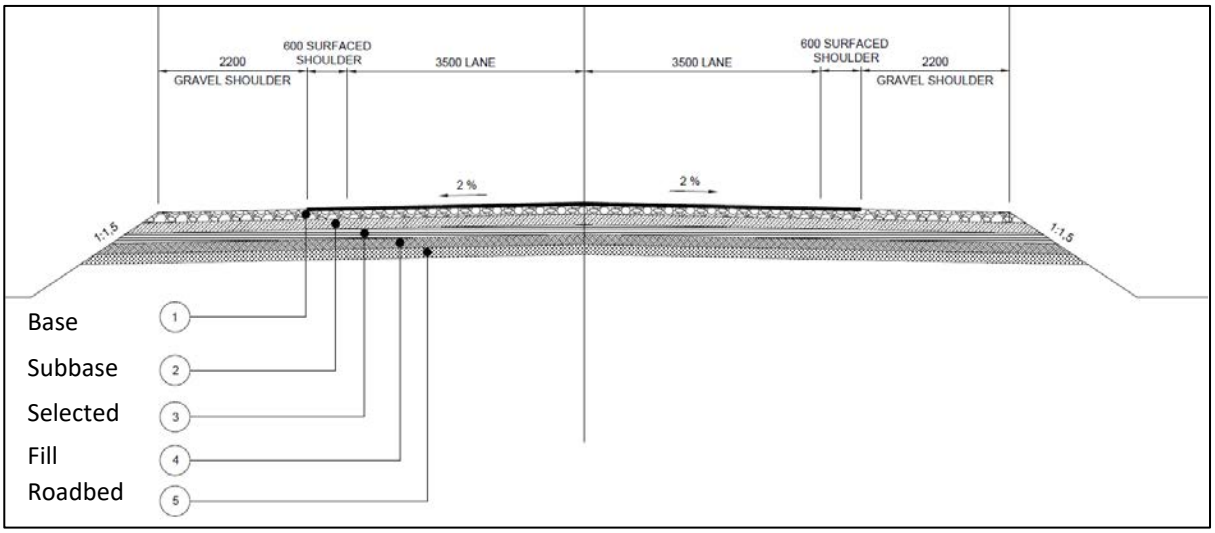

FIGURE 46: TYPICAL CROSS SECTION

The roadbed is the lowest in-situ layer. Fill is made up of the layers on top of the roadbed below the pavement layers (subgrade, subbase and base). The in-situ material, roadbed, is not always homogeneous and could vary. Sometimes three or five roller passes are specified instead of constructing the bottom in-situ layer.

Warning: Isolated soft spots could be present in the bottom in-situ layer. Do a visual inspection on the roadbed layer. Use a loaded truck to drive over the layer to identify soft spots that need to be stabilised or replaced with good material.

When heaving takes place under a loaded truck, the material is considered unstable. The Van der Merwe test could be done if minor heaving takes place to evaluate the suitability of the material.

Source: *VAN DER MERWE, D.H. 1964. The Prediction of Heave from the Plasticity Index and the Percentage Clay Fraction. Transactions. SAICE, Volume 6.*

12.1.1. HARD MATERIAL

If the roadbed consists of rocks or hard material, ripping or blasting may be required to the depth specified by the Engineer. The is done to improve the drainage in cuttings, e.g., to make sure that water is not trapped in hollow sections of rock under the road. The hard material may require blasting to prevent differential settlement.

Hard material is ripped 300mm at the centre and 500mm at the edges or as directed by the Engineer. See *COLTO 3305 d* for guidance.

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12.1.2. UNSUITABLE MATERIAL

Material that moves (heaving) when a loaded truck drives over it is considered unsuitable. Cracks will be seen when a loaded truck drives over the compacted layer.

Unsuitable material is treated in the following sequence of severity:

1. Remove the unsuitable material and replace it with better material.
2. If better material is not available, or too expensive to transport, the in-situ material could be stabilised. Note: If the clay content of the material is too high, it is not cost effective to stabilise it with cement or lime.
3. A 300mm to 500mm pioneer layer should be constructed, over water-locked or clay materials; the rocks will interlock to create a stable foundation.
4. If the depth of the unstable material is very deep, rockfill of 1m should be dumped into the unstable material. The depth of the rockfill should increase until a stable foundation is formed through interlocking of rocks.
5. If rockfill or pioneer layer is not available, geosynthetics have been used successfully. It is used for large unstable areas. The unstable material is excavated, geosynthetic material is placed at the bottom and sides, which are filled with sand or fill material.

FIGURE 47: UNSUITABLE MATERIAL

Note: Geosynthetics is also used to stabilise fill slopes.

Important: Contact geosynthetic supplier for advice on which product to use.

Advice: Refer to ***chapter 10*** for drainage of wet areas using drainage blanket or herring bone drains.

Note: The maximum thickness of a pioneer layer is 500mm. A rock layer > 500mm is called rockfill. The maximum rock size is 750mm.

12.2. Mass Earthworks

12.2.1. BORROW PITS

The Consultant directs from which borrow pit source material should be obtained for pavement layers.

It takes a considerable amount of time to register a new borrow pit with all the necessary environmental studies and approval from the Department of Mineral and Energy. In most cases existing registered borrow pits are utilised, or material is specified from commercial sources. The transport cost could be considerable, depending on the location of the project.

Important: Take photos before the borrow pit is used.

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Management of borrow pits:

The topsoil of the borrow pit should be removed and stockpiled separately. The topsoil is used for the rehabilitation of the borrow pit at the completion of the project. The overburden should be measured before it is removed by digging a few test holes in the borrow pit. The overburden is material that is not suitable for the required pavement layers. This material should be stockpiled separately and is used to rehabilitate the borrow pit to a 1:4 slope at the end of the project.

A designated area should be identified to spoil materials. A hole should be dug to bury broken pipes, concrete, and other waste materials.

Important: Borrow pits should be inspected to see if there is any variance that could be expected from the material.

The borrow pit should be fenced to prevent any animals from entering the borrow pits. The borrow pit should be closed or locked, for security reasons.

The borrow pit should be used in such a way that it drains.

The access road should be maintained, and the dust controlled.

12.2.2. CUTTINGS

Excavation of material is classed as soft material, intermediate material, or hard material, and is paid accordingly. The contractor should prove that material is intermediate or hard by making the necessary plant available.

Intermediate excavation is excavation (excluding soft material) in material which can be efficiently ripped by a bulldozer with a mass of at least 35 tons when fitted with a single ripper and an engine developing approximately 220kW at the flywheel.

Hard excavation shall be excavation (excluding boulder excavation) in material which cannot be efficiently ripped by a bulldozer as stated above. This type of excavation generally includes excavations in material such as formations of unweathered rock, which can only be removed after blasting.

Boulder class A is material containing 40% or more by volume of boulder between 0.03m^3 and 20m^3 in size, in a matrix of softer material or smaller boulders. Excavation of fissured or fractured rock shall not be classed as boulder excavation, but as hard or intermediate excavation, according to the nature of the material.

Boulder class B is material containing 40% or less by volume of boulders or lumps of hard dolomite ranging from 0.03m^3 to 20m^3 in size in a matrix of soft material or smaller boulders or lumps of hard dolomite. The rest of the excavation shall be classed as soft or intermediate excavation, according to the nature of the material.

Source: *COTO Chapter 4: Earthworks and Pavement Layers: Materials, Section 4.1: Borrow Materials, Part A4.1.7.2.b) Classes of excavation, page 4-19.*

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12.2.3. CRUSHING OF MATERIAL

Aggregate is stone that is crushed and screened to a certain grading.

Hard material is crushed to produce G1 to G5 material, concrete stone and/or seal aggregate.

Primary jaw crushers are used to break down the large rocks, e.g., rockfill, pioneer layers, and gabions. The opening of the jaw could be set to produce more smaller stones. Vibratory screens are used to screen out larger stones. The drilling spacing for blasting hard material and the opening setting of the jaw crusher is set to produce the optimum different sizes of material required.

Second stage crushing and screening may be required to minimise the waste when crushing material. Cone crushers are normally used to further crush the material into smaller fractions, with a specific grading e.g., G1 to G3 material.

Third stage crushing (tertiary crushing) or impact crushing, is used to make the aggregate more cubical (less flaky) for seal aggregates where the average least dimension (ALD) is specified e.g., 19mm, 14mm, 10mm, and 7mm.

Note: Material could also be broken down on the road by using grid rollers. If too much oversized material is produced, the holes for blasting should be made in a denser matrix.

Warning: Crushed stone should be tested after crushing 5 000m^3. Screening sieves need to be adjusted to ensure the grading of the crushed stone is correct. Continued crushing without verification of the grading could be very costly if the G1/G3 material is rejected.

12.2.4. FILL MATERIAL

Fill material is material used between the roadbed and the selected subgrade layers, normally G9 quality material. Rock used as fill material need not be tested. The compaction methods should be approved.

Important: High fills at bridge approaches should be constructed wider to allow space for guardrails. Fills to be constructed early in project to allow for settlement of in-situ material under the weight of the fill material.

12.3. Pavement Layers

Traffic load dissipates in the depth of the pavement layers. The top layer should be the strongest while the bottom layer carries the least load.

12.3.1. SELECTED SUBGRADE

The selected subgrade layers are primarily capping for the subgrade to provide a workable platform to construct the imported pavement layers. At the same time, these layers provide depth of cover over the subgrade to reduce the stresses in the subgrade to acceptable levels. Material used: G7 or G8.

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12.3.2. SUBBASE LAYER

The subbase layer provides support for the base as well as a platform upon which to construct a structural base layer of high integrity. It also protects the underlying selected subgrade layer by further spreading the load. Material used: G4 – G6.

12.3.3. BASE LAYER

The base layer is a load spreading layer that is the most important structural component of the pavement. The layer must provide the required support for the surfacing and distribute the very high tyre pressures and wheel loads uniformly over the underlying layers and subgrade. Materials used: Crushed stone G1 – G3, or gravel G4 - G6, depending on road class.

Surface finish

A rough surface finish of the base is preferred when placing asphalt on the base to reduce any shoving.

The surface finish is very important to be smooth when a seal is placed on the base. The moisture of the base is critical for a smooth surface finish, too much moisture and the layer disforms, too little moisture and the material pick up on the roller.

FIGURE 48: MATERIAL TOO WET MATERIAL DISFORMS

FIGURE 49: MATERIAL PICKED UP ON ROLLER DRUM

FIGURE 50: ROUGH SURFACE FINISH

FIGURE 51: SMOOTH SURFACE FINISH

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Advice: Vibration rollers start with low frequency high amplitude to compact the layer and change to high frequency, low amplitude for final top compaction, or else the vibrator roller will over compact and break up top layer. Cracks at close spacing will be visible when over compacting.

FIGURE 52: BASE SURFACE CRACKS DUE TO OVER COMPACTION WITH VIBRATION ROLLER

12.3.4. PAVEMENT DESIGN

The base layer needs to be the strongest layer. Base material could be stabilised with cement to increase the strength. However, stabilised layers crack, causing water ingress into the layer. Water saturates the pavement layers and weakens its bearing capacity. Base layers could be sealed with rubber seal to 'stretch' over the cracks. Base layers could also be stabilised with bitumen, reducing the moisture susceptibility.

The crushed stone layer is strong but flexible, thus there is no risk of cracking. These layers are very expensive, and muscle up when slushed, becoming very strong. This layer is water susceptible and may fail if covered with permeable asphalt instead of a bitumen seal.

The subbase layer under a crushed stone base layer is normally stabilised to give a strong support.

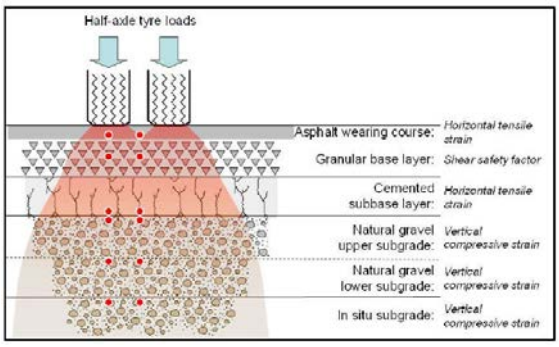

FIGURE 53: PAVEMENT LAYERS

Pavement layers for high traffic loads	Pavement layers for low traffic loads
40mm asphalt	14mm seal
150mm G1 base	150mm G4 base
300mm C4 subbase	150mm C6 subbase
300mm G7 subgrade	

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***Source of Figure 54**: SAPEM Chapter 10: Pavement Design, Figure 3: Stress Distribution in a Typical South African Flexible Pavement, page 5.*

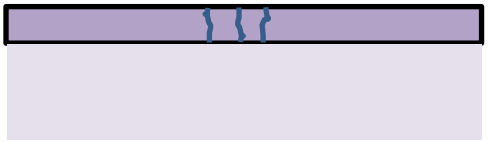

FIGURE 54: STABILISED BASE CRACKS WITHOUT SUPPORT UNDERNEATH

Warning: A stabilised base layer without a supporting layer underneath will crack. It's like placing glass on a sponge, it will crack under pressure.

Warning: Placing permeable asphalt over a crushed stone base in not advisable as water ingress will quickly damage the base. Seal with 10mm armour layer before placing asphalt to seal the base or place ultra-thin friction course (UTFC) with modified emulsion tack coat over the asphalt.

Advice: It is not advisable to construct an impermeable layer on the downstream side of a permeable layer, e.g., construction of stabilized base climbing lane next to gravel base in the fast lane. Water will be trapped at the joint. Rubber bitumen seal recommended.

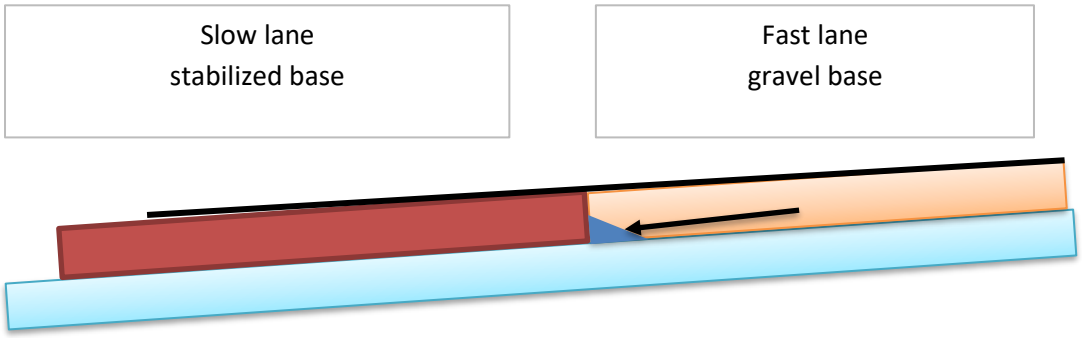

FIGURE 55: WATER TRAPPED AT JOINT BETWEEN STABILISED BASE AND GRAVEL BASE

12.4. Method Statements

The method of the construction of the mass earthwork and pavement layers should be discussed with the site agent, foreman, and laboratory manager before construction commences. The communication between the foreman, the laboratory manager, and site supervision staff should be established to ensure samples are taken correctly and timeously.

The following aspects should be addressed in the method statement for construction of layer works:

1. Maintenance of haul roads
2. The previous layer must be approved before the next layer could be placed
3. Any rain damage must be repaired, although the layer was accepted, before tipping the next layer
4. Drainage of layers during construction is required
5. Maximum size of material used as fill may not be > 500mm, except rockfill
6. Blasting methods must be changed if too much oversized material is removed that the grid roller cannot break down to construct the size required for the layer thickness
7. Widening of fill should be done by benching into the existing fill layer e.g., 0.5m.

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Important: It is the obligation of the Contractor to ensure that the material used for the different pavement layers comply to the specifications before it is tipped on site. The Contractor must inform the Engineer if there is any change in the quality of material from the borrow pit.

Danger: Vibration rolling over a shallow concrete structure, like a pipe culvert, will damage the structure. Only static rolling should be allowed over shallow concrete structures.

12.5. Supervision

12.5.1. CHECKLIST

The following main points should be checked when constructing layers:

1. Is the correct material used?
2. Is the moisture content correct?
3. Is the fill layer benched into the existing fill?
4. Is there any bridging?
5. Has a visual test with a truck been carried out to check pumping on the roadbed?

Refer to ***Appendix J9*** for a complete checklist.

FIGURE 56: BRIDGING

12.5.2. WORKSHEET

No worksheet needs to be completed for roadbed, fill, or selected material. There is, however, a worksheet required for stabilised layers, see ***Chapter 13.4.2.***

12.6. Tests

The following tests are done on pavement layers: Maximum dry density (MDD), grading, PI, CBR, and density.

Important: Fault lines may exist in the quarry or cuttings. The quarry and/or cutting should be inspected. Water, hardness of stone and soluble salts must be tested. Swell tests to be done on any slags. Test to be done to check for dispersive soils.

Refer to *South African Pavement Engineering Manual 13 Quality Management* for the testing frequency of the following:

1.	Selected layer	Table 4
2.	Subbase (non-cemented)	Table 5
3.	Gravel base G4	Table 7

12.7. Evaluation

Acceptance of layer work consists of evaluation of test results, levels, and visual inspection.

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Important: Visual inspections are very important. What is witnessed on site should be reflected in the test results, e.g., MDD, and moisture of material, and compaction effort. See moisture correction, ***paragraph 6.4.2***.

12.7.1. VISUAL INSPECTION

The completed layer should be visually inspected to identify any soft or loose spots in the layer. This can occur when there is loose material which prevents the steel wheel roller from compacting evenly across the surface. The width and the level of the layer should also be visually inspected.

When construction is done in half widths, check for compaction near the centreline joint, soft spots or loose material may be visible due to the bridging effect.

12.7.2. TEST RESULTS

The properties of the layer must meet the specified criteria as detailed on the drawings and/or project document. Refer to table 3402/5 in COLTO.

The Contractor should achieve between 90% - 100% of the density achieved in the site laboratory using the modified AASHTO compaction hammer. It is possible to achieve more than 100% compaction on site, as bigger equipment is used. The density achieved on site using heavy rollers is tested with a Troxler and compared to a sample of the same material that was compacted at optimum moisture in the laboratory. The 100% compaction reference is a sample at optimum moisture compacted using a 4.536kg tamper, dropping 457.2mm 55 times per layer in five layers, also called the modified AASHTO density or MOD. Optimum moisture is determined by reading the moisture required to achieve the optimum density from the graph by compacting the sample at different moisture contents. See graph below.

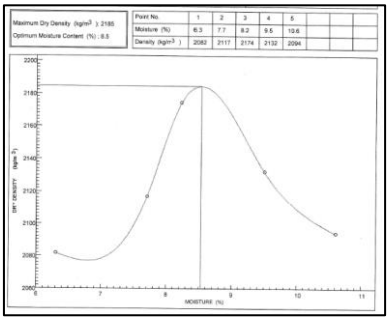

FIGURE 59: OPTIMUM MOISTURE DETERMINED IN THE LAB

FIGURE 58: MOD COMPACTION AT OPTIMUM MOISTURE

FIGURE 57: SITE COMPACTION WITH STEEL WHEEL ROLLER

Relative density means that the dry density on site is compared to the maximum dry density which was achieved with the same material that was tested in the laboratory and compacted to optimum moisture. The dry density is the wet density minus the moisture.

More than 100% compaction means that the roller on site is compacting relatively more than what is done in the laboratory with a MOD hammer.

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Summary of classification of material:

Material Class	Comp	LL max	PI max	LS max	Compact	CBR	Max swell @ 100%	GM max	GM min	10% FACT min kN
G5	95%	30%	10	5%	95%	45	0.5%	2.5	1.5	90
G5	95%	30%	10	5%	95%	45	0.5%	2.5	1.5	90
G6	95%		12		95%	25	1.0%	2.6	1.2	80
G7	93%		12		93%	15	1.5%	2.7	0.75	60
G8	93%		12		93%	10	1.5%	2.7	0.75	60
G9	93%		12		93%	7	1.5%	2.7	0.75	60
G10	90%		12							

The actual CBR of the layer depends on the compaction achieved on site, e.g., if the specified CBR at 95% should be met and the actual compaction was 98%, the CBR at 98% should be interpolated and used for the analysis of the layer.

Sand layer must be compacted to 100% density. Sand is classified in COTO (*Chapter 4: Earthworks and Pavement Layers: Materials, Section 4.1: Borrow Materials, Part A4.1.2 – Fill layers, page 4-2)* as 95% of material passing the 4.95mm sieve and less than 20% passing the 0.075mm sieve. The heel test is a quick check to see if the material is compacted, refer to ***example 6.5*** in ***paragraph 6.4.3***.

The correct evaluation scheme should be used for evaluation of layers. Refer to ***paragraph 7.3*** for statistical analysis of densities.

Moisture corrections should be done by testing with a Troxler. Troxler reading of wet density is correct, but dry density must be checked by heating it in the oven. See example in ***paragraph 6.4.2.***

12.7.3. LEVELS

The level and the thickness of the layer must comply with the specifications. H_{90} means that 90% of the levels taken must be within the specified tolerance, e.g., 15mm. See *COLTO 3405 a & b.*

Summary of level control:

Layer	H_{90}	H_{max}	D_{90}	D_{max}	D_{ave}
Selected	25mm	33mm	30mm	40mm	10mm
Subbase	20mm	25mm	21mm	27mm	5mm
Base	15mm	20mm	21mm	27mm	5mm
Shoulder & Wearing course		25mm		30mm	-0mm

Level control sheet shown in ***Appendix L.***

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Example of evaluation of levels submitted by the contractor:

LEVEL CONTROL										
Layer	Subbase		Section:	LHS		SB	- Lot of the Day			Date
										28/01/2021
SV	Design Level	Asbuild Level	Diff.	Design Level	Asbuild Level	Diff	Design Level	Asbuild Level	Diff	Remarks
	0.000	0.000		2.000	2.000		4.000	4.000		
80010	22.880	22.898	0.018	22.830	22.850	0.020	22.780	22.796	0.016	
80020	23.181	23.186	0.005	23.131	23.132	0.001	23.081	23.079	-0.002	
80040	23.783	23.755	-0.028	23.733	23.735	0.002	23.683	23.686	0.003	
80060	24.386	24.399	0.013	24.336	24.341	0.005	24.286	24.295	0.009	
80080	24.988	24.991	0.003	24.938	24.947	0.009	24.888	24.907	0.019	
80100	25.539	25.529	-0.010	25.489	25.492	0.003	25.439	25.442	0.003	
80120	25.785	25.771	-0.014	25.735	25.727	-0.008	25.685	25.688	0.003	
80140	25.691	25.715	0.024	25.641	25.651	0.010	25.591	25.605	0.014	
80160	25.258	25.265	0.007	25.208	25.222	0.014	25.158	25.165	0.007	
80180	24.485	24.485	0.000	24.435	24.434	-0.001	24.385	24.386	0.001	
80200	23.424	23.429	0.005	23.374	23.388	0.014	23.324	23.333	0.009	
80220	22.382	22.385	0.003	22.332	22.335	0.003	22.282	22.292	0.010	
80240	21.467	21.472	0.005	21.417	21.426	0.009	21.367	21.377	0.010	
80260	20.681	20.678	-0.003	20.631	20.608	-0.023	20.581	20.584	0.003	
80280	20.023	20.019	-0.004	19.973	19.975	0.002	19.923	19.923	0.000	
80300	19.494	19.484	-0.010	19.444	19.449	0.005	19.394	19.394	0.000	
Count		Hmax	16		Hmax	16		Hmax	16	
Rejected Count		0	1		0	0		0	0	
		1	1		0	1		0	0	
R/Count			2			1			0	
% Rejected			13			6			0	
% Accepted			88			94			100	
				H90			Hmax			
			0.0	2	4	Total	1			
	% Out of Tolerance		13	6	0					
	% In Tolerance		88	94	100	Ave%	93.8			

Specification for subbase:

H_{90} = 20mm
H_{max} = 25mm

Analysis:

Total number of levels 48.
Subbase levels < 25mm is #3.
Levels within specification is
48 - 3 = 45
H_{90} = 45/48 = 93.8 > 90.0 thus good.
H_{max} = 28mm > 25mm, thus rejected.

12.7.4. ACCEPTANCE

After all the criteria has been met (density, CBR, grading, PI, levels, visual inspection) the Resident Engineer can sign off and comment on the layer that was submitted for approval. The package is then stapled together, and the layer works register is signed.

The staff member responsible for supervision of the layer signs off and comments on the visuals, materials, and levels of the layer.

The following forms are signed off and form part of the package that is stapled together:

1. Test request from Contractor
2. Random positions and tests to be done issued to the laboratory manager
3. Laboratory test results submitted by the laboratory manager
4. Levels submitted by the surveyor or dips taken by the foreman
5. Checklist of supervision staff
6. Statistical analysis of test results
7. Final comment on inspection request by Resident Engineer
8. Signed off inspection request register.

The Resident Engineer makes a final decision and will write one of the following comments:

- Accepted
- Rejected
- Reduce payment
- Re-test
- Remedial actions required
- Monitor defects.

Refer to *South African Pavement Engineering Manual 13 Quality Management, Chapter 3.6 page 36* for Assessment of Non-Conforming Work.

The layer can now be paid according to findings of the Resident Engineer.

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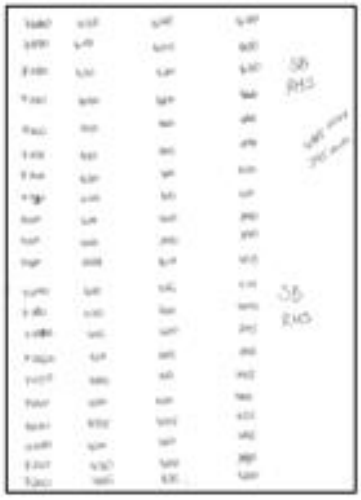
Example of signed package:



Important: Write an email if a section is not accepted and state what is required before the next layer can be constructed. It is no use rejecting the layer on paper, and nobody on site knows about it.

Refer the matter to the Engineer if the Contractor keeps on disregarding instructions. Refer to ***paragraph 24.7***.

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12.8. Payment

Payment for layer works is made for compacted volume, in cubic meters. No payment is made for overlaps etc.

Subgrade layers are measured from the typical cross section drawing.

Fill layers should be measured by a surveyor. If tallies are used, truck volumes should be measured. Ensure that trucks are fully loaded. Compacted volume = 0.7 x loose volume.

It is difficult to keep track of big fill areas that are constructed. Measuring two days later another 5 000m^3 could have been tipped. Payment on tally sheets or by measurement could be inaccurate. Contractors can easily fabricate extra tally sheets loads. The same applies to calculating haulage.

Advice: Agree the final fill quantity with the Contractor. Pay the Contractor each month a percentage of the final quantity based on a visual assessment. This prevents arguments about quantities at the end. Do the same for haul distance.

Haul distance is calculated from the middle of the borrow pit to the middle of the layer. The layer should be divided into sections that fall outside the free haul distance, normally 1km.

Excavation of hard material is classified as material that is blasted.

Note: Refer to ***paragraph 12.2.2*** *(COLTO 3303 a i, ii and iii)* for definitions of soft intermediate and hard material.

Example of payment of cut to fill:

Payment Item		Description	Unit	Rate	Quantity	Amount	
33.04		Cut to spoil, including free-haul up to 1,0 km. Material obtained from a) Soft excavation	m^3	R 100.00	100	R 10 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	5	Km 5,0 to km 5,6 RHS 600m x 2.3m x 0.15m		207	207		
		Slope km 12,4 tallies: 6 – 8 October 2021	5.2	108	315		

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13. STABILISATION

Material is stabilised to improve its properties, e.g., increase UCS strength or decrease PI. Stabilisation could be done with lime or cement or with emulsion/foam bitumen and cement.

A distinction is made between modification and stabilisation of material.

Modification: Lime or cement is mixed into the material, to lower the PI of the material, or it could be modified through blending better material with the existing material, to increase the strength of the layer, CBR.

Cement stabilisation: Gravel material is mixed with cement to increase the strength of the layer.

Warning: Too much cement will cause the stabilised layer to crack excessively, ITS > 300kPa[1]. Cement content added to gravel base or subbase layers is normally 1% to 2.5%. Stabilising over 3.5% cement is not recommended. Lime is normally added if the PI (clay content) of the material is too high.

Rule of thumb: PI less than 10 – cement stabilization, PI > 10 – lime stabilization[1].

[1]Paige-Green P (2008) A reassessment of problems affecting stabilized layers in roads in South Africa. *Proceedings of the 27th South African Transport Conference (SATC 2008), Pretoria, South Africa,* 7-11 July 2008, pp. 125-134

Warning: If the material is bad, it should be replaced, not stabilised. Refer to grading guideline in table 3.3 page 19 in the Asphalt Academy's *Technical Guideline: Bitumen Stabilised Materials (TG2), second edition, 2009*.

Bitumen stabilisation: Refer to *Technical Guideline: Bitumen Stabilised Materials (TG2), third edition, 2020*. Base layers are stabilised to increase the strength and 'flexibility' of the layer and to increase the moisture susceptibility of the material. Strength is gained without cracking.

Emulsion or foam bitumen is mixed into gravel material and cement is added. The cement must not be more than 1% and the cement content should not exceed the net bitumen content, e.g., 1% cement mixed with 2% emulsion (2% / 0.6 = 1.2%). If this ratio is not correct the layer is not classified as bitumen stabilised material (BSM), also called emulsion treated base (ETB).

*Emulsion consists of 60% bitumen and 40% water.

Important: Good gravel material should be used to stabilise base or subbase layers. Low quality material should be replaced or blended with good material before stabilisation.

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13.1. Designs

The stabilisation design is done on site. This should be done two months before stabilisation starts.

Refer to Table 26 on page 91 of the *South African Pavement Engineering Manual, Chapter 13: Quality Management* for the testing of the water to be used. *COLTO 3502 e* specifies that water used for diluting emulsions must be clean and free from many salts that will break the emulsion during dilution. Water must be tested for compatibility with the prescribed stabilising agent.

13.1.1. CEMENT STABILISED LAYERS

Samples of the material that will be stabilised must be obtained to do the stabilisation design. If the material will be recycled, then the recycled material must be used. The Contractor must make his plant available so the stabilisation design could be done correctly. The water that will be used during construction must be used for the stabilisation design.

Important: The actual material and water that will be used for stabilisation must be used to do the stabilisation design.

The following test will be done with the neat material: MDD, grading, PI, CBR.

The material will then be mixed with the expected target cement plus 0.5% and 1.0% below and above the target, e.g., target 2.0%: mix with 1.0%, 1.5%, 2.0%, 2.5%, and 3.0%. These mix proportions are tested for MDD, grading, PI, UCS, and ITS. The UCS and ITS are pressed using rapid 24-hour curing, 7-day curing, and 28-day curing. The initial consumption of stabilizer (ICS) must also be done, see paragraph on carbonation below. All this information is used to complete the D5 (design) form. (See the SANRAL D1 to D5 forms)

The minimum amount of cement that could be effectively spread on a 150mm stabilised layer is 1.0%.

The actual cement needed for the specified layer, like C3, is obtained from the design. Aim for the lower end of the specification. Add 0.5% cement to allow for site conditions, thicker layer and cement not evenly spread.

COLTO Table 3402/6:

Criteria	C1	C2	C3	C4
Material before treatment	Min G2	Min G4	Min G6	Min G6
Compaction	**100%**	**100%**	**100%**	**100%**
UCS kPa max	12000	6000	3000	1500
UCS kPa min	6000	3000	1500	750
ITS kPa min			250	200
Compaction	**97%**	**97%**	**97%**	**97%**
UCS kPa max	6000	4000	2000	1000
UCS kPa min	4000	2000	1000	500
Durability	Carbonation specified in project specification			

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Danger: Carbonation takes place in certain materials after being stabilised. The chemical reaction causes the material to become unstable and decompose and/or disintegrate.

Carbonation

The durability of material is tested using the (initial consumption of lime) ICL method. The required stabilizer is read from the graph when further addition of lime results in no increase in pH. The material does not fully carbonate when ICL is exceeded by 1%. The engineer must make an informed decision if additional 1% stabilizer becomes excessive. If the pH drops below 10, cementation becomes unstable, and reversal of strength development occurs over time. Tensile values are more important mainly in calcretes and basic crystalline materials e.g., dolerite.

FIGURE 60: CARBONATED TOP 25MM,3% CEMENT STABILISED GRANITE

Proper curing of stabilised layers prevents carbonation from taking place. Stabilised material must be kept moist for at least seven days, either by periodic water spraying (recommended three times per day), covering the layer with plastic sheeting, spreading the next layer, or priming with emulsion. Wet/dry cycles should be avoided.

See ***paragraph 13.6.2*** for carbonation testing using phenolphthalein.

Source: Refer to Paige-Green P (2008) A reassessment of problems affecting stabilized layers in roads in South Africa. *Proceedings of the 27th South African Transport Conference (SATC 2008), Pretoria, South Africa,* 7-11 July 2008, pp. 125-134.

Photo of carbonation: De Beer, M, Netterberg F, Weak interlayers in flexible and semi-flexible road pavements, Part I, *Journal of the South African Institution of Civil Engineering, Vol 54 No 1, April 2012, page 32-42, Paper 762-1.*

13.1.2. BITUMEN STABILISED LAYERS

The following tests are done on the neat sample: MDD, grading, PI and CBR, durability mill index (DMI).

Danger: One of the most important aspects of the untreated aggregate is durability. Refer to *TG2, table 4.1, page 27, second edition, 2009* for the DMI limits for rocks and soils.

Depending on the traffic on the road, level 1 to level 3 mix design is done. Refer to *TG2, paragraph 4.5, page 40, second edition, 2009* for an overview of the procedure of level 1 to level 3. Refer to *TG2, paragraph 4.1.2, page 36* for the detailed procedure.

Level 1 mix design: traffic < 3 MESA, use 100mm specimens for ITS testing, dry and wet.
Level 2 mix design: traffic > 3 MESA, use 150mm specimens for ITS, equil and soaked.
Level 3 mix design: traffic > 6 MESA, use 150mm moulds for triaxle test.

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Advice: When the existing base material is stabilised with a recycler for a high-level mix design, a neat sample of the existing base should not be taken using a pick and shovel. The neat sample for the stabilisation design should be taken from material that was pulverised by the recycler, as the grading of the existing base will change.

The neat material is normally mixed with 1% cement and different percentages of bitumen, e.g., 2.0%; 2.5%; and 3.0%.

The existing base material may be modified, for example, by adding 20% – 50% G5 material to improve the grading. Stabilisation design should be done after the modification of the neat sample.

Design criteria for BSM as follows (TG2 table 4.6 page 39):

Test	Specimen diameter	BSM 1	BSM 2	BSM 3	Description
ITS_{dry}	100mm	> 225	175 – 225	125 – 175	Indicates optimum bitumen content.
ITS_{wet}	100mm	> 100	75 – 100	50 – 75	Indicates need for active filler.
TSR	100mm	N/A	N/A	N/A	Indicates problem material where TSR < 50 and ITS_{dry} > 400kPa
ITS_{equil}	150mm	> 175	135 – 175	95 – 135	Optimise bitumen content
ITS_{soaked}	150mm	> 150	100 – 150	60 – 100	Check value on ITS

Tensile Strength Retained (TSR) is ITS_{wet}/ITS_{dry} x 100.

The amount of bitumen and cement will be determined from the test results and compared to the BSM layer that is specified in the project document or drawings. Refer to *TG2, second edition, 2009, table 3.2 on page 18,* for specification for BSM1, BSM2, and BSM3 pavement types.

Summary of Bitumen Stabilised Material (BSM) classes:

BSM1: High traffic roads, good material stabilised
BSM2: Medium traffic roads, fair material stabilised
BSM3: Low traffic roads, poor material stabilised.

13.2. Trial Sections

A trial section is required for BSM layers to ensure the correct quantity bitumen, water, and cement is mixed into the material, and that the compaction is achieved with the plant that is used. The slushing and surface finish must be satisfactory.

Trial sections for cement stabilised layer are necessary, especially when using recyclers for mixing and a bulk tanker to spread the cement. The even spreading of cement is not so critical when using graders, as the grader mixes the material in the transverse direction. Recyclers do not mix cement in the transverse direction, and even cement spreading is very important.

The surface finish of base layers that will be sealed needs to be of a high standard. The surface finish of subbase layers or base layers with asphalt on top is not so critical.

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13.2.1. CEMENT STABILISATION

13.2.1.1. Bulk Tankers

During the trail section, the spread rate of the cement must be measured using a 1m canvas. A titration test is to be done to determine the cement content in the layer.

13.2.1.2. Cement Bags

Spreading of cement using cement bags could be done very accurately. A trial section is required when the base layer is stabilised with cement. The quality of the surface finish will be tested and visually inspected for acceptance. The method statement may need to be adjusted to achieve the correct surface finish.

13.2.2. EMULSION STABILISATION

Most recyclers cannot set the emulsion pump speed separately from the speed the recycler is driving. The recycler speed must thus be maintained to ensure the correct amount of emulsion is added. Pulverising hard material, like BTB patches, may be required before stabilisation to ensure that a constant speed could be maintained.

The speed and flow chart needs to be submitted by the Contractor, demonstrated during the trial section, and verified with dip stick reading in the emulsion tank before and after stabilisation.

13.2.3. FOAM BITUMEN STABILISATION

A trial section is very important for quality assurance of foam bitumen.

Foam bitumen is produced by injecting water (and air in some systems) into hot bitumen, resulting in spontaneous foaming. Special equipment is used for foam bitumen, e.g., Wirtgen recycler, or batch plant. Caterpillar recyclers cannot foam bitumen. The flow of the bitumen and the pressure of the water/air is important to ensure the bitumen bubbles are big enough and last long enough to mix

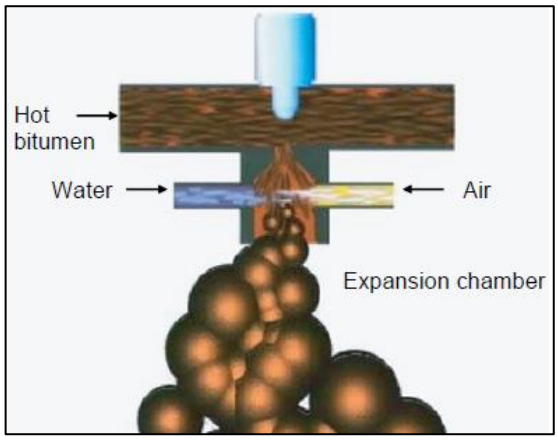

FIGURE 61: FOAM BITUMEN STABILISATION

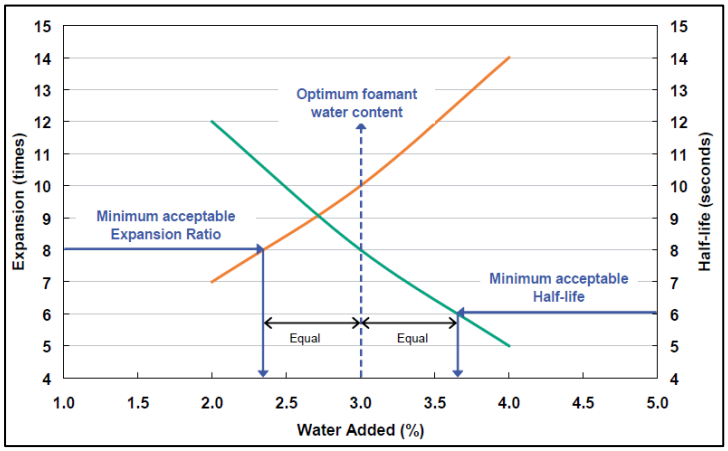

FIGURE 62: DETERMINATION OF OPTIMUM FOAMANT WATER CONTENT

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before they burst. There is a balance between the expansion and half time before the bubble (foam) bursts. Refer to *TG2, second edition, 2009, figure 4.3 on page 31*.

***Source of Figure 61**: Technical Guideline 2, May 2009, Figure 2.2 Foamed Bitumen Production in Expansion Chamber, page 4.*

***Source of Figure 62**: Technical Guideline 2, May 2009, Figure 3.4 Determination of Optimum Water Content, page 31.*

13.3. Method Statements

The method statement must include any pre-treatment and pulverising of hard material that may be required.

Hold point: **Pre-shaping levels are to be approved by the supervision team before stabilisation.**

Warning: The cutting edges of the grader may be worn out, resulting in the construction of a hollow cross section of the base. Cutting edges should be checked and replaced regularly.

Important: Take levels in between wheel paths, especially when paving asphalt over the base layer.

Danger: Vibration rolling over a shallow concrete structure, like a pipe culvert, will damage the structure. Only static rolling should be allowed over shallow concrete structures.

13.3.1. CEMENT

The even spreading of cement is important, especially when using a recycler, as cement is not mixed across the width of the layer. Blocks should be marked out for each cement bag to be spread. Using rubber rakes to spread the cement works effectively.

Tip: Pull a thick rope over the cement after it was spread with rakes/squeegees to ensure the cement is spread evenly, especially if more than 1.5% cement is used, or the stabilised layer is thicker than 150mm.

The curing of cement stabilised layers during the first seven days is important, and should be stated in the method statement.

13.3.2. BITUMEN

The bitumen tank must be dipped before and after each pull. Flow records are to be submitted to the Resident Engineer.

The depth of the layer should be checked at 100m intervals.

Nozzles should be flushed after each day's work.

Blocked nozzles should be clecked and cleaned each morning.

Flushing with diesel is not permitted on the pavement layers, as it creates a weak spot.

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13.3.3. EMULSION

The correct amount of water must be added to the emulsion to obtain the optimum moisture for the BSM layer. Clean water may **not** be used afterwards to reach the optimum moisture content. Measuring the moisture in the existing layer is critical to determine the total amount of water that should be added to the emulsion before stabilising the material.

Slushing with emulsion could be tricky as the emulsion breaks and material sticks to the roller and plucks out chunks of base material. Slushing should be done in 50m lengths. The moisture of the top layer must be carefully monitored.

13.3.4. FOAM BITUMEN

Regular checks must be performed to check the half time and expansion of the foam.

13.4. Supervision

13.4.1. CHECKLIST

The following main points should be checked when stabilising layers:

1. Pre-shape, is there enough material?
2. Is the cement/lime evenly spread?
3. Is the moisture content correct?
4. Is there any bridging?
5. Ensure that there are not biscuit layers.
6. Are layers being cured?

See ***Appendix J10*** for a complete checklist.

13.4.2. WORKSHEET

A worksheet needs to be completed and signed by both the Consultant and the Contractor. See ***Appendix K3*** and ***Appendix K4*****.** It is important to record the start and end time for stabilisation. The time starts when the cement is in contact with water and stops when vibration rolling is finished.

Note: Cement will hydrate and form strong bonds in the moist gravel. Vibration should be completed within 6 – 8 hours, before bonds are fully formed. Vibration after this time will break down the bonds and should be avoided. Refer to the project specifications for the time limits or COLTO table 3503/1.

COLTO table 3503/1:

Stabilising agent	Time limit
Ordinary Portland cement, and blends	8 hours
Slaked lime	10 hours
Unslaked lime	10 hours

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13.5. Tests

Refer to *South African Pavement Engineering Manual 13, Quality Management, Table 9* for the testing frequency of stabilised layers.

The following tests are done on stabilised material: UCS, ITS, MDD and indicator (grading & PI). Refer to the project specifications if UCS and/or ITS must be done.

13.5.1. SAMPLES

Samples should be taken before compaction and not after. It is not advisable to dig a sample hole in the base layer after it was compacted, as it leaves a weak spot.

13.5.2. CEMENT STABILISATION

UCS and ITS are required for cement stabilisation, refer to the project specification or drawings for details. UCS and ITS must be cured for seven days before it is tested. Rapid curing for 24 hours could also be done: the results are not accurate, but they give an indication of what the seven-day cured results would be. Rapid curing is done as an early warning system.

13.5.3. BITUMEN STABILISATION

ITS is required for bitumen stabilisation, refer to *TG2, table 3.2, page 18*, the project specification, or drawings for details. ITS_{dry} and ITS_{wet} are tested.

13.6. Evaluation

The density, ITS and UCS results are statistically analysed. The grading and PI are evaluated. The Contractor is not responsible for achieving ITS or UCS results, but only for adding the required lime/cement/bitumen as specified in the mix design to the layer.

Important: It is the responsibility of the Resident Engineer to ensure that correct amount of stabilising agent was used, spread evenly, and mixed homogenously.

Contractors start tipping in the next layer, if the densities of the subbase layer pass, to cure the layer. This is done before the layer is accepted or the UCS or ITS results are out (10 days later). Permission may be granted to start tipping, provided that the levels have passed, and visual inspection has been done.

13.6.1. VISUAL INSPECTION

Visual inspection is important. The Resident Engineer should walk each layer before approving the layer.

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13.6.1.1. Surface Finish

The smooth surface finish of base layers that are covered with asphalt is not so important; the asphalt 'sticks' better to the base if it is more on the coarse side.

The surface finish of a base that will be sealed must be smooth with only minor surface irregularities, refer to ***paragraph 12.3.3***. The layer should be rejected if extensive coarse sections are visible. If this continues to happen, the method of construction must be changed, and another trial section must be submitted for approval, until a smooth surface finish can be achieved.

Minor surface irregularities can be corrected with base repairs. Deep sections should not be repaired with slurry, as the seal aggregate will punch into it. Isolated large sections could be corrected with an asphalt scratch coat, but it is better to rebuild the layer if the base corrections become extensive. It is also more cost effective to rebuild the base than spending twice as much money on corrections!

Important: If the surface of the **base** layer is too rough, it should be rejected rather than being excessively repaired.

This is especially true at the beginning of the project. It is better to reject the base layer and set a good standard than repairing a fair base finish that could have been done better. This sets a bad example, which could impact on the quality of future work.

The base repair method is to be approved to correct surface irregularities. See ***paragraph 13.6.5*** for guidance.

13.6.1.2. Soft Spots

The completed layer should be visually inspected to identify any soft or loose spots in the layer. The width and the level of the layer should also be visually inspected.

13.6.1.3. Joints

When construction is done in half widths, check for compaction near the centreline joint, soft spots or loose material may be visible due to the bridging effect. See sketch in ***paragraph 12.5.1*.**

13.6.1.4. Laminations

The layer should be checked for laminations. A chain could be pulled. A hollow sound will be heard when lamination (biscuit layer) was constructed. A geological hammer can also be used to identify laminations indicated by hollow sounds.

FIGURE 63: CHAIN TEST AND GEOLOGICAL HAMMER USED TO IDENTIFY LAMINATIONS

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13.6.2. TEST RESULTS

The properties of the layer must meet the specified criteria as detailed on the drawings and/or project document. Refer to Table 3402/6 in COLTO**.** See ***paragraph 13.1.1*****.** for summary of table.

Moisture corrections should be done by testing with a Troxler. See ***paragraph 6.4.2.*** for an example.

The correct evaluation scheme must be used for evaluation of layers.

The actual UCS/ITS of the layer depends on the compaction achieved on site, e.g., if the specified UCS at 97% should be met, and the actual compaction was 99%, the UCS at 99% should be interpolated and used for the analysis of the layer.

Warning: The test results must not be blindly accepted as correct; they must be analysed. What is on paper must resemble what was seen on site.

Ask these questions when evaluating test results: Does the MDD and moisture content, used to calculate the density of the layer, look correct? Was the compaction on site done with the correct equipment and moisture?

Important: Rejecting a layer without understanding why it failed is not advisable. Respect from the Contractor is earned by thorough investigation before decisions are made to reject a work, for example, was the sample taken correctly, without the material drying out?

Phenolphthalein turns dark red when applied to cement stabilised material and becomes paler until it becomes colourless at pH <9. Cement stabilised material effervesces on the addition of diluted hydrochloric acid. This is a good indication to determine whether the material was stabilised with cement, or carbonation took place.

FIGURE 64: ILLUSTRATION OF PHENOLPHTHALEIN REACTION ON CEMENT STABILISED GRANITE. UPPER PORTION WITH NO PHENOLPHTHALEIN REACTION (DARKER COLOUR) INDICATES CARBONATION

Source: Paige-Green P (2011) Considerations for ensuring durability of chemical stabilized road materials. *Proceedings of the Institution of Civil Engineers Ground Improvement (Nov 2011)*

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13.6.3. LEVEL

The level and the thickness of the layer must comply with the specifications. H90 means that 90% of the levels taken must be within the specified tolerance, e.g., 15mm. See *COLTO 3405 a & b.*

Important: It is important to take levels in between the wheel paths, especially when paving asphalt over the base layer. Asphalt quantity may increase by 50%, if the level on the outside is 30mm, and the level between wheel paths is 45mm, and still within level tolerance.

Summary of level control:

Layer	H90	Hmax	D90	Dmax	Dave
Subbase	20mm	25mm	21mm	27mm	5mm
Base	15mm	20mm	21mm	27mm	5mm

See ***paragraph 6.3*** for an example of statistical evaluation of base levels. See ***Appendix L*** for level template.

Refer to ***paragraph 14.6.4*** for details on international roughness index.

Refer to ***paragraph 14.6.5*** for an evaluation of surface irregularities.

13.6.4. ACCEPTANCE

After all the criteria has been met, the Resident Engineer can sign off and comment on the layer that was submitted for approval. The package is then stapled together, and the layer works register is signed.

The staff member responsible for supervision of the layer signs off and comments on the visuals, materials, and levels of the layer.

The Resident Engineer makes a final decision and will write one of the following comments:

- Accepted
- Rejected
- Reduce payment
- Re-test
- Remedial actions required
- Monitor defects.

The following forms are signed off and form part of the package that is stapled together:

1. Test request from Contractor
2. Random positions and tests to be done issued to the laboratory manager
3. Laboratory test results submitted by the laboratory manager
4. Levels submitted by the surveyor or dips taken by the foreman
5. Worksheet and checklist of supervision staff
6. Comments of visual inspection done be supervision staff
7. Statistical analysis of test results
8. Final comment on inspection request by Resident Engineer
9. Signed off inspection request register.

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See ***Appendix B4*** for a register, ***Appendix C*** for test requests and random density positions, ***Appendix E4*** for an inspection request, and ***Appendix G*** for statistical evaluation. Statistical analysis spreadsheets will be made available if you participate in the Resident Engineer Mentorship Programme.

The layer can now be paid according to findings of the Resident Engineer.

Important: Write an email if a section is not accepted and state what is required before the next layer can be constructed. It is no use rejecting the layer on paper and nobody on site knows about it.

13.6.5. REMEDIAL WORK

Cement stabilised layers could be reworked once by adding 50% of the initial cement content into the layer. When the layer fails again, the stabilised material must be replaced with new material[1].

[1]***Source:*** *South Africa Pavement Engineering Manual 13 Quality Management, par 4.6.3, page 46.*

Base repairs are to be done as remedial work for surface irregularities. If the repair work is too extensive, the layer should be rejected and rebuilt. The surface finish is not critical when the base layer will be covered with asphalt; in fact, a rough surface is preferable so the asphalt will not move on the base.

Surface repairs are to be done thoroughly when the base will be sealed.

A guideline for repairing surface irregularities: Asphalt could be used or a mixture of crushed stone < 5mm and emulsion with a bit of cement.

13.7. Payment

Payment for layer works is made for compacted volume, in cubic metres. Refer to the typical cross section in the drawings for the width and depth of the layer.

The measurement for adding material should be done by a surveyor, who should measure the level before and after tipping. If tallies are used, truck volumes should be measured. Ensure that trucks are fully loaded. Compacted volume = 0.7 x loose volume.

Extra over-payment is made for mixing of stabilised material. The actual cement and bitumen are paid up to a maximum tolerance of +/-5%. Layers stabilised above the 5% tolerance will not be paid, and could be rejected by the Engineer. Layers stabilised below the 5% tolerance may be rejected by the Engineer.

Source: *COTO Chapter 5: Earthworks and Pavement Layers: Construction, Section 5.4: Stabilisation, Part A5.4.8.4.a) Rates of application, page 5-69.*

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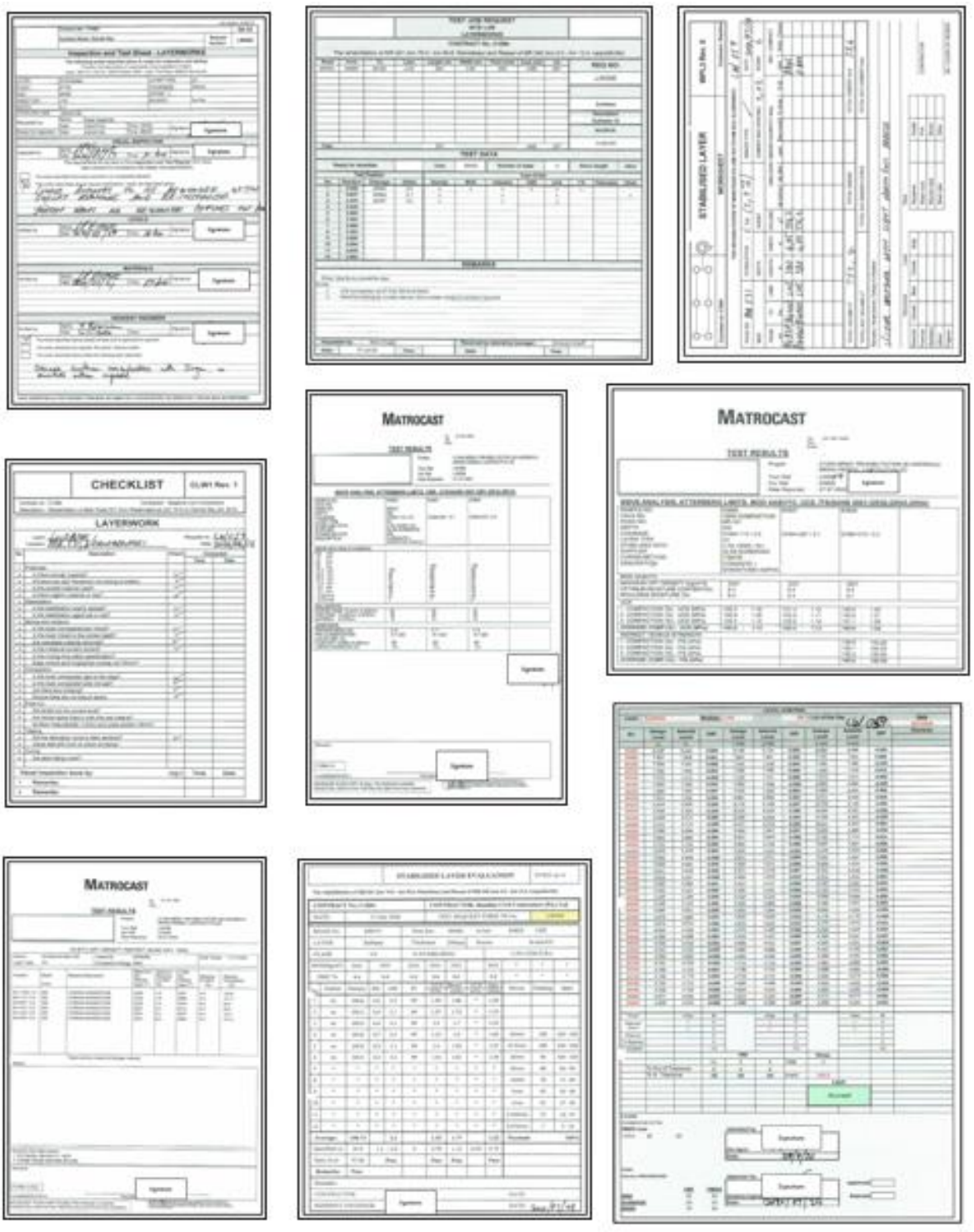
Example of package to be signed and filed:



Example 13.1: Calculation for foam stabilisation

Stabilised layer:	length 500m, width 4m, and depth 150mm.
Maximum dry density =	2 160kg/m^3
Stabilisation design:	1.25% cement, 1.5% net bitumen.
Volume = L x W x D =	500 x 4.0 x 0.15 = 300m^3

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Foam bitumen calculation:

Bitumen (ton) = volume x MDD/1000 x 1.5% bitumen
= 300 x 2 160kg/m^3 / 1 000 x 1.5% = 9.72 tons

Cement calculation:

Cement (t) = volume x MDD / 1 000 x 1.25% stabilisation
= 300 x 2 160kg/m^3 / 1 000 x 1.25% = 8.10 tons

Example 13.2: Calculation for emulsion stabilisation

Stabilised layer:	length 500m, width 4m, and depth 150mm.
Maximum dry density:	2 160kg/m^3
Stabilisation design:	1.25% cement, 2.5% emulsion (1.5% net bitumen).
Volume = L x W x D =	500 x 4.0 x 0.15 = 300m^3

Note: SS60 Anionic emulsion consists of 60% bitumen and 40% water; thus 2.5% x 60% = 1.5% net bitumen.

Emulsion calculation:

Emulsion (litres) = volume x MDD x 2.5% emulsion
= 300 x 2 160kg/m^3 x 2.5% = 16 200 litres

Cement calculation:

Cement (t) = volume x MDD / 1 000 x 1.25% stabilisation
= 300 x 2 160kg/m^3 / 1 000 x 1.25% = 8.10 tons

Example of emulsion and cement measurement and payment backup:

Payment Item		Description	Unit	Rate	Quantity	Amount	
35.02		Chemical stabilising agent g) CEM II 32,5N	Ton	R 1 400	1 000	R 1 400 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/14	10	SV 8 000 – SV 10 000 RHS					
		1 200 x 2 160kg/m^3/ 1 000kg/t x 1,25%	10.1	32.4	32.4	MK	JB

Payment Item		Description	Unit	Rate	Quantity	Amount	
35.02		Chemical stabilising agent h) (a) Anionic stable grade bituminous emulsion (60% net bitumen)	Litre	R 5.50	2 000 000	R 11 000 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/14	10	SV 8 000 – SV 10 000 RHS	10.1	66 110	66 110	MK	JB

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Backup Excel spreadsheet for stabilising:

Design 1.25% cement and 1.5% net bitumen. Thus 1.5% / 0.6 = 2.5% emulsion. MDD 2 160kg/m^3.

Date	Req. no.	Layer	SV	SV	Pos	Width	Thick	Vol	Emulsion required	Emulsion used	Difference	% diff	Emulsion paid
14/10/14	B012	Base	4320	4820	RHS	4.00	0.15	300	16 200	16 500	300	1.9%	16 500
15/10/14	B013	Base	8500	9000	RHS	4.00	0.15	300	16 200	17 300	1 100	6.8%	17 010
16/10/20	B014	Base	9000	9500	RHS	4.00	0.15	300	16 200	16 900	700	4.3%	16 900
17/10/14	B015	Base	9500	10000	RHS	4.00	0.15	300	16 200	15 700	–500	–3.1%	15 700
Oct								1200	64 800	66 400	1 600		66 110

Note: Date 15/10/14 Maximum payment +5% tolerance = 16 200 x 105% = 17 010 litres.

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14. CRUSHED STONE

Crushed stone is not only a strong material but also flexible. It is very costly to crush the rock to a specific grading. The dense packed grading of G1 to G3 material makes the layer strong enough to resist pressure without cracking like stabilised layers. The slushing out of the air and the 0.075mm material is critical in order to successfully reach the necessary density and thus the strength of the layer.

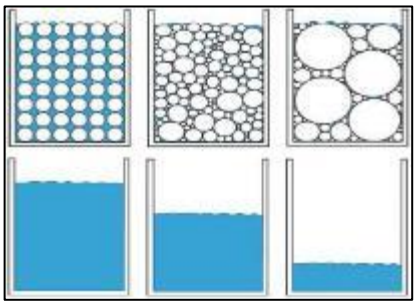

FIGURE 65: GRADING OPTIMISED FOR MAXIMUM DENSITY

14.1. Approval of Material

The main tests are:

1. Grading (coarse sand ratio) and PI
2. Aggregate Crushing Value
3. 10% Fine Aggregate Crushing Value
4. Fractured faces

Other important tests:

5. Water
    a) Acidity pH
    b) Conductivity
    c) Minerals
6. Hardness
    a) Ethaline Glycol
    b) Methanol Blue
7. Soluble salts

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The material that will be used for the crushed stone base must be approved. The Contractor must submit a sample for approval of the material. The material must comply to the following specifications in the project specification and **COLTO 3602**.

Table 3602/1		G1	G2	G3	
Parent material		Sound rock, or clean sound boulders	Sound rock, boulders, or coarse gravel	Sound rock, boulders, or coarse gravel	
Additional fines		Only fines crushed from the same sound parent, rock LL <= 25, PI <=4	May add up to 10% natural fines, LL <= 25, PI <=6	May add up to 15% natural fines, LL <= 25, PI <=6	
Flakiness		<= 35			
Fractured Faces		All faces fractured	For crushed materials, at least 50% of fractions retained on each standard sieve 4.75mm and larger shall have at least one fractured face		
Fraction -0.425mm		LL <= 25, PI <= 5, LS <= 2%	LL <= 25, PI <= 6, LS <= 3%	LL <= 25, PI <= 6, LS <= 3%, Calcrete PI <=8, LS<=170	
Fraction -0.075mm		PI <= 12, if chemical modified PI<=8		If chemical modified PI <=10	
Nominal maximum size		37.5mm	37.5mm	37.5mm	26.5mm
Grading	Nominal size of sieves (mm)				
	37,5	100	100	100	
	26,6	84 – 94	84 – 94	84 – 94	100
	19,0	71 – 84	71 – 84	71 – 84	85 – 95
	13,2	59 – 75	59 – 75	59 – 75	71 – 84
	4,7\5	36 – 53	36 – 53	36 – 53	42 – 60
	2,00	23 – 40	23 – 40	23 – 40	27 – 45
	0,425	11 – 24	11 – 24	11 – 24	13 – 17
	0,075	4 – 12	4 – 12	4 – 12	5 – 12
Coarse sand ratio		> 35 not exceed 50% in target grading	> 35 not exceed 50% in target grading	> 35 not exceed 50% in target grading	
Compaction		88% ARD	85% BRD	98% or 100% MOD	

Warning: Although crushed stone is a durable material, fault lines with smectites, etc. may exist in the quarry. The quarry should be inspected. Water, hardness of stone, and soluble salts must be tested. Swell tests must be done on any blast furnace slags. Aggregates without fractured faces do not interlock.

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14.2. Trial Sections

A trial section should be constructed before 5 000m^3 of crushed stone is produced, to prove the quality and compatibility of the material and to agree the target grading.

Important: The grading of the crushed stone stockpile may be within the specified grading, but mixing and compaction may lead to further breaking down of the material and may fall outside the required grading envelope.

A 150m – 200m trial section should be placed on a layer of specified subbase standard. When the trial section fails, it shall be removed as excess/unsuitable material before a further trial section may be constructed.

Danger: The crushed stone layer must not be mixed over and over with water as the bigger aggerate will settle at the bottom of the layer and the fine material on top, thus the layer will not 'muscle up', and mechanical interlocking will not be achieved.

The approved target grading from the trial section after compaction shall be as near as possible to the mean of the specified grading in ***COLTO table 3602/1*** and is subject to the following requirements, unless substantive evidence relating to the crushing characteristics of the parent rock and its impact on the shear characteristics and compatibility of the structural layer is given:

For 37.5mm maximum size aggregate

- -0.075mm shall be between 7% and 9%
- -0.425mm fraction shall not exceed 22%
- -2.00mm fraction shall not exceed 34%
- -4.75mm shall be between 40% - 45%
  - Needle shaped flakiness index > 25 the target is 45%
- -2.00mm +0.425mm fraction shall not be less than 35% nor more than 50% of the -2.00mm fraction (coarse sand ratio).

Table 3602/4 Tolerances on target grading

Sieve size (mm)	Permissible deviation for mean values (% by mass)		Permissible deviation for mean values (% by mass)	
Nominal max size	37,5mm	26,5mm	37,5mm	26,5mm
26,6	±5		±5	
19,0	±5	±5	±7	±7
13,2	±5	±5	±7	±7
4,7\5	±4	±4	±7	±7
2,00	±4	±4	±5	±5
0,425	±3	±3	±5	±5
0,075	±2	±2	±3	±3

For 26.5mm maximum size aggregate

- -0.075mm shall be between 7% and 9%
- -2.00mm +0.425mm fraction shall not be less than 35% nor more than 50% of the -2.00mm fraction (coarse sand ratio)
- -4.75mm shall be between 40% - 50%.

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The mean grading of the approved trial section is used as the target grading unless the above criteria is not met, thus the target grading may vary from the mean grading of the trial section. Once the target grading is approved, ***Table 3602/1*** is no longer used for acceptance control but rather ***Table 3602/4***, for tolerances on the target grading.

The layer should not be too wet when compacting, as the material will pick up on the wheels. The percentage 0.075mm sieve is critical in order to reach the desired compaction.

14.3. Method Statements

No crushed stone layer shall be tipped if the underlying layer is so wet as to constitute a danger of the underlying layers being damaged.

Tips for the construction of crushed stone bases:

1. The percentage of 0.075mm is critical for achieving density and good riding quality (IRI).
2. Levels should be set out at 10m intervals (alternating level pole colours every 20m for each direction) when IRI specifications are applicable.
3. Tipping intervals of crushed stone must be accurate, to prevent moving material in the longitudinal direction, causing it to segregate.
4. The width and the thickness of the layer should be carefully monitored to limit waste.
5. Water should be sprayed after flattening half the tipped material to prevent segregation of the fine material from the coarse material.
6. Some contractors 'soak' the crushed stone in water for two days before compaction, to allow stone to absorb the water.
7. After compaction, the layer should dry out before slushing.
8. Slushing should be done in 50m sections, adding fine material on coarse sections.
9. Use a 3m straight edge when IRI specification is required, to ensure that the level is correct.
10. The completed layer must be protected by placing poles or old tyres on the road, obstructing vehicles from driving on the completed layer.
11. The G3 base should be protected with a blinding layer (grid or sand) at access roads and intersections.
12. The layer should be primed as soon as the top 50mm has dried out to 50% of optimum moisture content (OMC).

Danger: Vibration rolling over a shallow concrete structure, like a pipe culvert, will damage the structure. Only static rolling should be allowed over shallow concrete structures.

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14.4. Supervision

14.4.1. CHECKLIST

The following should be checked when constructing crushed stone layers:

1. Ensure that the layer underneath is approved and dry.
2. Check that the crushed stone is not contaminated with the shoulder or other material.
3. Look for coarse sections, fine material to be added when slushing.
4. Crushed stone should not be over compacted when slushed; stop when no more bubbles are visible in front of the steel wheel roller or when too many fines are visible in the windrow.
5. The cutting blade should be straight, (replace cutting edges regularly).
6. The layer needs to be protected from public driving; the layer may be rejected after it was approved when rain or vehicle damage is visible.

See ***Appendix J11*** for a complete checklist.

14.4.2. WORKSHEET

No worksheet is required to be completed. Any delays or change in method or equipment or weather delays should be recorded in your personal diary.

14.5. Tests

Refer to *South African Pavement Engineering Manual 13 Quality Management Table 6* for the testing frequency of crushed stone layers.

Important: It is very important to sample correctly, full depth, removing all the dust using a brush.

Danger: The Troxler could give wrong readings when measuring the compaction of a crushed stone layer. Calibrate Troxler readings with sand patch densities.

14.6. Evaluation

The crushed stone layer is evaluated for grading, density, levels, and visual inspection.

The crushed stone layer may be rejected after it has been approved, due to vehicle or rain damage. Final approval needs to be given before prime.

If the surface texture is too rough (more than 20%) it should be rebuilt and not repaired with base corrections, especially at the beginning of the project when the standard is set!

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14.6.1. VISUAL INSPECTION

The completed layer should be visually inspected to identify any coarse sections or section with too much dust. The mosaic of the larger stone should be visible. Too much fine material on top is problematic. Too coarse a surface when sealing is also problematic. A coarse surface with asphalt is not a problem. Cracks are visible when the compacted material is too wet. These sections must be dried out and recompacted before surfacing

A base repair method is to be approved to correct surface irregularities. See ***paragraph 14.6.5*** for guidance.

Important: If the surface of the **base** layer is too rough, it should be rejected rather than being excessively repaired.

This is especially true at the beginning of the project. It is better to reject the base layer and set a good standard than repairing a fair base finish that could have been done better. This sets a bad example, which could impact on the quality of future work.

14.6.2. TEST RESULTS

The grading of the crushed stone must pass the individual grading specification and the average grading specification, see ***Table 3602/4.***

Outlier critical C values for compaction and grading are specified in *COLTO Table 8204(d)/3.*

The specified density of the crushed stone layer may the reduced, based on the discretion of the engineer.

14.6.3. LEVELS

The level and the thickness of the layer must comply with the specifications. H90 means that 90% of the levels taken must be within the specified tolerance, e.g., 15mm. See *COLTO 3405 a & b.*

Important: It is important to take levels in between the wheel paths, especially when paving asphalt over the base layer. Asphalt quantity may increase by 50% if the level on the outside is 30mm and between wheel paths is 45mm, and still within level tolerance.

Summary of allowable tolerance for level control:

Layer	H90	H_{max}	D90	D_{max}	D_{ave}
Base	15mm	20mm	21mm	27mm	5mm

Level and thickness control sheets are included in ***Appendix L***.

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14.6.4. INTERNATIONAL ROUGHNESS INDEX (IRI)

The international roughness index is a measurement of the levels of the road in the wheel path. The measurement is used in an algorithm to determine the riding quality of a sedan motor driving at 80km/h. Different weights are given to undulations, level difference between front and back wheels (bumps), and corrugations.

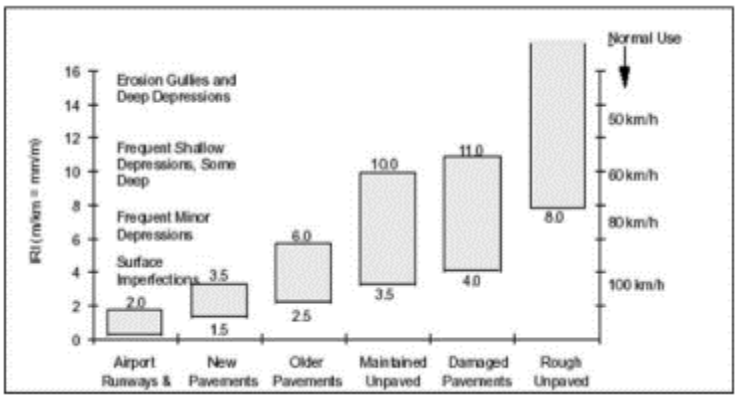

FIGURE 66: SUMMARY OF THE SCALE OF IRI

IRI is measured with a profilometer.

Important: The profilometer must have a calibration certificate.

Source of figure 66*: Ahmed Elghriany, Investigation of the Effect of Pavement Roughness on Crash Rates for Rigid Pavement, April 2015 Journal of Transportation Safety & Security 8(2):00-00 DOI:10.1080/19439962.2015.1025458, Figure 41. Range of values of international roughness index (replotted from Sayers et al., 1986).*

14.6.5. SURFACE IRREGULARITIES

The surface irregularities are measured longitudinally with a 3m rolling straight edge as follows:

- The number of surface irregularities exceeding 5mm taken over 100m should not be more than #6.
- The average number per 100m of surface irregularities exceeding 5mm taken over 300m – 600m should not be more than #4.
- The base repair method must be approved to correct surface irregularities.

Source*: COLTO 3405 Construction tolerances f) surface regularity page 3400-6.*

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Example of evaluation of surface irregularities:

SV	Depth	Specification Number #6 over 100m	Specification Ave #4 over 300m	SV	Depth	Specification Number #6 over 100m	Specification Ave #4 over 300m
120	7mm	Total 6 over 100m Pass <=6	Total 6+5+4=15 over 300m Average over 300m: 15/3=5 (100m sections) Fail 5>=4	620	7mm	Total 7 over 100m Fail >6	Total 7+1+2=10 over 300m Average over 300m: 10/3=3,3 (100m sections) Pass 3,3>=4
130	8mm			630	8mm		
140	6mm			635	6mm		
150	6mm			650	7mm		
160	6mm			655	6mm		
190	9mm			660	9mm		
220	7mm	Total 5 over 100m Pass <=6		670	6mm		
250	6mm			720	7mm	Total 1 over 100m Pass <=6mm	
260	8mm						
280	6mm			830	8mm	Total 2 over 100mPass <=6mm	
290	7mm			860	8mm		
310	6mm	Total 4 over 100m Pass <=6		920	11mm	Fail > 10mm	Fail > 10mm
330	9mm						
340	7mm						
390	6mm						

14.6.6. ACCEPTANCE

The Engineer has the discretion to reduce the density specification of crushed stone. After all the criteria has been met, the Resident Engineer can sign off and comment on the layer that was submitted for approval. The package is then stapled together, and the layer works register is signed.

The staff member responsible for supervision of the layer signs off and comments on the visuals, materials, and levels of the layer. See ***Appendix B5*** for register, ***Appendix C*** for a test request and random locations for density, ***Appendix E5*** for an inspection request, and ***Appendix H*** for statistical evaluation.

The following forms are signed off and form part off the package that is stapled together:

1. Test request from Contractor
2. Random positions and tests to be done issued to the laboratory manager
3. Laboratory test results submitted by the laboratory manager
4. Levels submitted by the surveyor or dips taken by the foreman
5. Checklist of supervision staff
6. Comments of visual inspection done be supervision staff
7. Statistical analysis of test results
8. Final comment on inspection request by Resident Engineer
9. Signed off inspection request register.

The Resident Engineer makes a final decision and will write one of the following comments:

- Accepted
- Rejected
- Reduce payment
- Re-test
- Remedial actions required
- Monitor.

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Refer to *South African Pavement Engineering Manual 13 Quality Management, Chapter 3.6 page 36 for Assessment of Non-Conforming Work*.

The layer can now be paid according to findings of the Resident Engineer.

Important: Write an email if a section is not accepted and state what is required before the next layer can be constructed. It is no use rejecting the layer on paper and nobody on site knows about it.

14.6.7. REMEDIAL WORK

Base repairs to be done as remedial work for surface irregularities. If the repair work is too extensive, the layer should be rejected and rebuilt.

Surface repairs to be done thoroughly when the base will be sealed. Guideline for repairing surface irregularities: Asphalt could be used or a mixture of crushed stone and emulsion with a bit of cement, e.g., 10 shovels of crusher dust plus 250mℓ cement plus 5ℓ – 10ℓ emulsion (colour must not be dark).

14.7. Payment

Only the approved trial section will be paid for. No payment is made for removal of failed trial sections. Partial payment may be made for densities or grading that is borderline, subject to the approval of the Engineer/Client.

Payment Item		Description	Unit	Rate	Quantity	Amount	
36.01		Crushed stone base: e) Constructed from type G3 material obtained from commercial sources (37,5mm nominal maximum size) and compacted to i) 87% of bulk relative density (150mm thick)	m^3	R 700.00	20 000	R 14 000 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	10	Km 80,0 to km 84,0 RHS 4000m x 4,15m x 0.15m		2 490	2 490		

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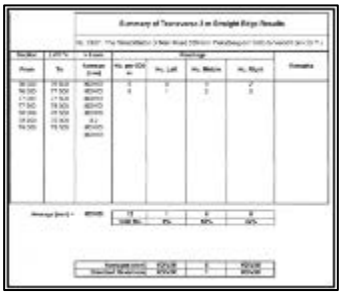
Example of package to be signed off and filed:



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15. GRAVEL WEARING COURSE

15.1. Approval of Material

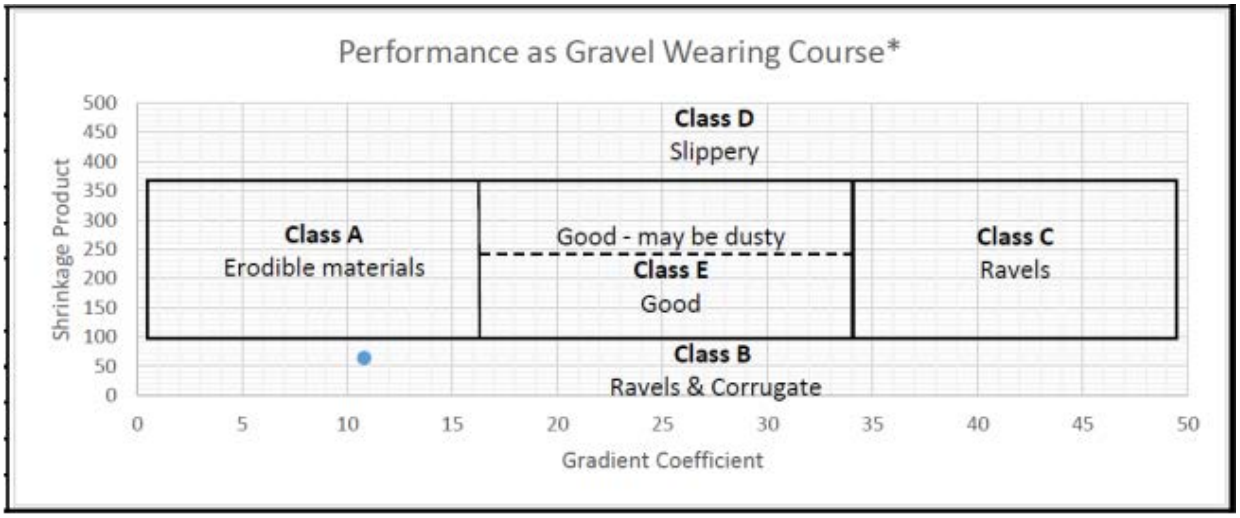
Gravel wearing course material is not always available to meet the specified criteria in ***COLTO 3402/4***. The material must have a clay content to reduce the dust, but not so much that it becomes slippery. The grading must be correct to prevent ravelling and corrugations.

COLTO table 3402/4:

Parameter	Limit	
	Type 1	Type 2
Maximum size, mm	37,5	37,5
Oversize index (Ix), (max) %	<=6	0
Shrinkage product (Sp)	100 – 365 Pref < 240	100 – 240
Grading coefficient (Gc)	15 – 34	15 – 34
CBR at >= 95% modified AASHTO compaction (soaked value), (minimum) %	>= 15	>=15

Ix = oversize index (percent retained on 37.5mm sieve)
Sp = Linear shrinkage x (percent passing 0.425mm sieve)
Gc = (percent passing 26.5mm – percent passing 2.0mm) x percent passing 4.75mm

Influence of parameters on the performance of the layer as follows:



Materials may need to be blended to get the desired properties, e.g., mixing existing base with G5 top up material.

Engineering discretion should be used for the strict implementation of the specifications, e.g., ravel and corrugation are not an issue when a gravel wearing course is used on an access road with low speed.

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Although material like calcrete does not always have enough PI, it still has a cementing property and could work well as gravel wearing course. This should be evaluated by doing a trial section.

15.2. Trial Sections

Trail sections are recommended, especially if materials are blended, to see how the layer performs.

15.3. Method Statements

The Contractor must submit a method statement for construction of a gravel wearing course.

Guidelines of points to be clarified in the method statement for construction of gravel wearing course[1]:

1. Optimise spacing holes for blasting to reduce quantity oversize material.
2. Stockpiling of material. High stockpiles to be done in layers as large stones keep rolling to the bottom.
3. Correct loading from stockpiles, through the full face of the stockpile.
4. Blending ratio if material obtained from two sources.
5. Pre-shaping and breaking down of larger stone in bottom layer.
6. Grid roller weight and speed, e.g., 13.5 tons at minimum 12km/h.
7. Crushing of material if Treton value is less than 20.
8. Mixing of blended material.
9. Removal of oversize material by hand or grader.
10. Compaction equipment.
11. Traffic accommodation.
12. Density test within 12 to 24 hours after compaction.
13. Retests: Note that additional wet rolling on top 50mm to 60mm with vibrating roller, incorrect amplitude or frequency may reduce density.

[1]***Source:*** *Western Cape Provincial Government, Materials Manual, Chapter 19 rev 0, Acceptance Control Gravel Wearing Course, page 19.6-19.7, Comments, page 19.9-19.10- Compaction.*

Note[2]: The Shrinkage Product (Linear Shrinkage x percentage passing the 0.425mm fraction) is a major indicator for the performance of expected performance of the material. If high plasticity cannot be reduced successfully by means of mechanical stabilisation (adding of soil binder) without reducing the bearing strength, the addition of road lime may be considered, but is not as normal for a gravel wearing course. The lime modifies the active clay to a non-active state without unnecessarily cementing the material.

[2]***Source:*** *Western Cape Provincial Government, Materials Manual, Chapter 19 rev 0, Acceptance Control Gravel Wearing Course, page 19-6, Atterberg limits.*

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15.4. Supervision

15.4.1. CHECKLIST

See ***Appendix J9*** for checklist.

15.4.2. PROGRESS

A personal diary should be used to track the progress and record any delays, breakdowns, or later delivery of material.

15.5. Tests

Refer to Western Cape Provincial Administration Materials Manual Chapter 8 Revision 2 Quality Assurance, table 8-73, page 8-74.

Tests to be performed include the following:

- Density
- MDD
- Moisture content
- Grading
  – oversize index
  – grading coefficient
- Atterberg limits
  – shrinkage product
- CBR

15.6. Evaluation

The evaluation of the density of the gravel wearing course is the same as other pavement layers. The grading of the material is used to calculate the Shrinkage product, and grading coefficient. The properties are evaluated against ***Table 3402/4 in COLTO.***

15.7. Payment

The payment of the layer is the same as other layer works. If tallies are used, truck volumes should be measured. Ensure that trucks are fully loaded. Compacted volume = 0,7 x loose volume.

Payment Item	Description		Unit	Rate	Quantity	Amount	
34.01	Pavement layers constructed from gravel taken from cut or borrow, including free-haul up to 1,0 km; or constructed from gravel or crushed stone obtained from commercial sources (unlimited free- haul): (h) Gravel wearing course compacted to: (ii) 95% of maximum dry density (Type 2 material from commercial source)		m^3	R 430.00	1 000	R 430 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	10	Km 82,0 to km 82,5 RHS 500m x 4,0m x 0.15m		300	300		

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16. PRIME

The prime has a low viscosity and penetrates into the base.

The main function of a prime is to penetrate the layer to which it is applied, while leaving a small residual amount of binder on the surface to promote **adhesion** between the base and the newly applied bituminous base or surfacing. A prime cannot be assumed to be an impermeable membrane and that it will prevent any ingress of moisture during rainy weather.

Source: *South African Pavement Engineering Manual Chapter 9: Materials Utilisation and Design, Section 7.1.1: Definition and Functions of a Prime, page 41.*

Crushed stone base layers should be primed as soon as possible, as the layer easily ravels as it dries out. The prime binds the top fine particles. It helps protect the base against rain damage. Primed crushed stone bases should not be opened to traffic as the surface will soon start ravelling. The same is true for gravel bases with low PI.

Prime is not required on bitumen stabilised bases, as the bitumen already binds the layer. The top of ETB or BSM layers are slushed, thus binding the top layer.

Prime is also used on cement stabilised bases. Although the cement binds the gravel, it could ravel after some time. Cement stabilised layers have successfully been sealed without a prime.

16.1. Material

16.1.1. APPROVAL OF PRIME

The type of prime is specified in the Bill of Quantities. Contractors do submit alternative products as new products come into the market. The alternative prime must comply with the specifications, mainly viscosity. The flashpoint and application temperature are also important.

Warning: Heating the prime too much could cause the prime to ignite by itself!

Prime mainly consists of bitumen and paraffin, and some 'soap'. Prime with too little paraffin does not penetrate dense base layers. Prime with too much paraffin penetrates well but takes long to dry and softens the seal or asphalt on top.

The approval of the prime is best done through illustration in a trial section.

16.1.2. BLINDING

Specification for blinding aggregate: crushed rock or river sand 100% passing 6,7mm sieve and <10% passing 2,36mm sieve. Aggregate shall be clean, hard, and free from excessive dust, and without any clay, loam, or other deleterious material.

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16.2. Trial Sections

It is essential to do a trial section before priming a layer. Prescribed products and alternative proposal of products from the contractor should be applied on a completed 1m^2 base at different application rates, e.g., 0.7ℓ/m^2, 0.8ℓ/m^2, and 0.9ℓ/m^2. The base layer needs to be dampened with water before the prime is applied. The sections will be left to dry. The penetration of each application and drying time are recorded and used to decide which product performs the best.

FIGURE 67: TRIAL SECTIONS FOR PRIME

16.3. Method Statements

The Contractor must submit a method statement for application of the prime.

Warning: The layer to be primed must be approved before prime is applied.

The following should be addressed in the method statement:

1. All dust, dung, mud, etc. must be removed before prime is applied.
2. String lines are to be used for guidance of distributor, nails are required at 10m intervals and 3m around corners.
3. Reinforcing paper is required at the start and end of each spray.
4. Drip strip is required at the end of each spray.
5. Prime is to be applied at the correct temperature. Check flashpoint for safety.
6. Top 50mm of base should be <= 50% of OMC.
7. Weather condition to determine if prime could be applied, no rain or strong winds.
8. Blinding of prime required at intersections.
9. Dampen the base layer before brooming off the dust, otherwise too many fines are removed, leaving a coarse surface that may require base repairs before sealing. A coarse surface is not so critical when putting asphalt on top of the base.
10. Use soft brushes on mechanical brooms.

16.4. Supervision

16.4.1. CHECKLIST

The checklist from the *South African Pavement Engineering Manual 12, page 95* could be used, see ***Appendix J12***.

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The main points to check are:

1. Granular base < 50% of OMC
2. Dampen base before spray
3. Use correct binder type
4. Blinding for traffic accommodation
5. No prime should be applied when rain is threatening, when it is misty, or when there are strong winds.

Damp crusher dust should be used to absorb surplus prime. The prime overlap on the longitudinal joint is 100mm.

Weather limitations: No prime should be applied during foggy or wet conditions, or when rain is imminent, or wind that could cause uneven spraying, or when the surface is visibly wet, or if the temperature is likely to fall below 10 degrees Celsius.

The Contractor is to give 24-hour notice to the Engineer of his intention to prime.

16.4.2. WORKSHEET

The same worksheet used for seal work is completed. See ***Appendix K5***.

16.4.3. BLINDING

Blinding is used to protect the wet prime and base after it is applied from damage caused by vehicles at access roads and intersections that must be opened for traffic.

Source: COLTO 4102 Materials, b) Aggregate for blinding, page 4100-1.

Apply blinding two to four hours after the application of prime where practical at 285m^2/m^3.

16.5. Tests

The following tests are required:

1. A bakkie test
2. Grading of blinding layer
3. The moisture of the top 50mm of the base should be less than 50% of OMC.

16.6. Evaluation

Spray rates for prime are evaluated the same as for seal work. Over sprays should be blinded with damp crusher dust and the excess material removed.

No ‘fisheyes’ should be visible. The layer is either not dampened before spraying the prime, or the prime application is too little.

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16.7. Payment

Payment for prime is actual litres sprayed, up to a maximum of 0.06ℓ/m^2.

Example of overspray:

Required prime application rate is 0.80ℓ/m^2. This rate was given in a site instruction by the Resident Engineer after the evaluation of the trial section.
Actual application: Start dip 12 000 litre, end dip 9 000 litre. Length 800m, width 4.2m.
Actual spray rate = litres used / area = (12 000 – 9 000) / (800 x 4.2) = 3 000 / 3 360 = 0.89ℓ/m^2
Maximum payment = required spray rate + tolerance = 0.80 + 0.06 = 0.86ℓ/m^2
Prime paid = allowed application rate x area = 0.86 x 3 360 = 2 890 litres.

Example of under spray:

Required prime application rate is 0.80ℓ/m^2.
Actual application: Start dip 9 000 litre, end dip 7 200 litre. Length 600m, width 4.2m.
Actual spray rate = litres used / area = (9 000 – 7 200) / (600 x 4.2) = 1 800 / 2 520 = 0.71ℓ/m^2.
Minimum tolerance is 0.80 – 0.06 = 0.74 ℓ/m^2.

The actual application rate is below the accepted tolerance. The prime is thus rejected and must be rectified.

It is up to the engineer's discretion to accept a lower application rate and payment will only be made for what was applied, thus 1 800 litres.

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17. SEAL

Seal is a bituminous layer that covers the base layer and prevents ingress of water. The bitumen oxidises (becomes brittle) over time, and cracks. Seals need to be rejuvenated as they become brittle. This is normally done with a fog spray (diluted emulsion). The road could also be resealed or covered with a slurry.

Warning: Slurry seals do not seal cracks. Cracks will come through a slurry seal.

17.1. Designs and Approval of Aggregate

17.1.1. STOCKPILE AREAS

The stockpile area for the seal aggregate must be submitted to the Engineer for approval. A permission letter from the landowner must be submitted. A letter must also be obtained that the owner is satisfied with the area after construction is completed.

Important: Stockpile areas must be dust free, with good drainage, and free from mud.

Tip: Truck signs should be placed at the stockpile access road.

17.1.2. APPROVAL OF AGGREGATE

The following tests are to be done for approval of the seal aggregate:

1. Grading
2. Flakiness
3. Aggregate crushing value (ACV)
4. 10% FACT
5. Polishing stone value (PSV) of the aggregate (Special test)
6. Average least dimension (ALD).

Danger: The aggregate delivered to site should be sampled for grading and ALD. Sampling aggregate at the quarry could be problematic, as the grading and the ALD of the material delivered to site is not the same aggregate that was sampled at the quarry.

The ACV, 10% FACT, and PSV of the parent rock must not differ in stockpiles at the quarry, but the grading and dust content may.

Other important tests:

1. Hardness
    a) Ethaline Glycol
    b) Methanol Blue

Warning: Although crushed stone is a durable material, fault lines with smectites, etc. may exist in the quarry. The quarry should be inspected.

Important: The dust content of the aggregate must not be too high, watch when aggregate is off-loaded and give an early warning if the dust content looks too high.

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Refer to *South African Pavement Engineering Manual 13 Quality Management, Table 17* for the testing frequency of pre-delivered seal aggregates.

17.1.3. PRE-COATING

Aggregate is precoated to increase the adhesion of the stone to the binder. Precoating is not required when sealing with emulsions. Precoating agent needs to be approved.

The application rates of precoating must be determined and measured on site. Add precoating until no more white spots are visible on the stone. Adding too much precoating will contaminate the environment.

Application rates for precoating, *South African Pavement Engineering Manual 13 Quality Management Table 19*:

Stone size (mm)	6,7	9,5	13,2	19
Litre/m3	16 – 22	14 – 18	12 - 14	10 – 12

17.1.4. BITUMEN BINDERS

FIGURE 68: MEASURE NEEDLE PENETRATION INTO BITUMEN

Bitumen is a residue of crude oil. Crude oil is heated, and different products are extracted from the vapor, like paraffin, petrol, diesel, oil, etc. The bottom black material that is left behind is bitumen.

The softness or toughness of bitumen is determined by measuring the penetration of a needle into the bitumen at 25°C. In soft bitumen the needle penetrates 150mm to 200mm and in tougher bitumen it only penetrates 35mm to 50mm and is called 35-50 pen bitumen.

The softness or toughness of the bitumen correlates directly to the softening point and viscosity (resistance to flow) of the bitumen. The softening point is the temperature where the bitumen starts to soften (flow) and is determined by steadily heating bitumen in a ring with a ball on top in water from 0°C till it starts melting and drops a distance.

FIGURE 69: DETERMINE SOFTENING POINT

FIGURE 70: FLOWABLE BITUMEN

Bitumen needs to be heated to make it flow. Tougher (harder) bitumen needs to be heated to higher temperatures than softer bitumen, and therefore has a high viscosity (high resistance to flow). Viscosity is measured in Pascal seconds (Pa.s).

Tough (hard) bitumen, with high resistance to flow, is used in hot conditions, as it is tough and does not easily deform in hot weather. It becomes brittle in cold weather and cracks.

Soft bitumen is used in cold temperatures, as it does not become brittle and crack, but in hot temperatures, it becomes too soft and will bleed or deform (flow).

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FIGURE 72: BITUMEN TOO SOFT

FIGURE 73: BITUMEN TOO BRITTLE

FIGURE 71: POTHOLES – INGRESS OF WATER

Bitumen is modified to enhance its properties to be softer in cold temperatures (less brittle) and harder in hot temperatures (less flowable/deforming).

Paraffin is added to bitumen to make it softer, which is called cut-back bitumen. This is used in winter to prevent stripping (cold night temperatures make bitumen brittle and causes stone loss on seals).

Danger: Volatiles (paraffin) in cutback bitumen need time to evaporate. Laying a seal or slurry too early (less than 2 – 4 weeks depending on weather and traffic) will cause the volatiles to be trapped and will soften the bitumen, which could cause extensive bleeding during summer.

Emulsion is also used to seal roads in winter. Bitumen is emulsified with water, e.g., 40% water. After application, the water evaporates and only the bitumen is left. Emulsion need not be heated and could be sprayed at ambient temperatures. Stable grade emulsions break (water evaporates) after 3-4 hours depending on the weather. They break more quickly in hot windy weather. Spray grade emulsion usually breaks 1-2 hours quicker.

Warning: Emulsion in tanks and drums need to be circulated or turned regularly, as the bitumen settles to the bottom over time.

Summary of bitumen binders, *Sabita Manual 2 Bitumen binders*:

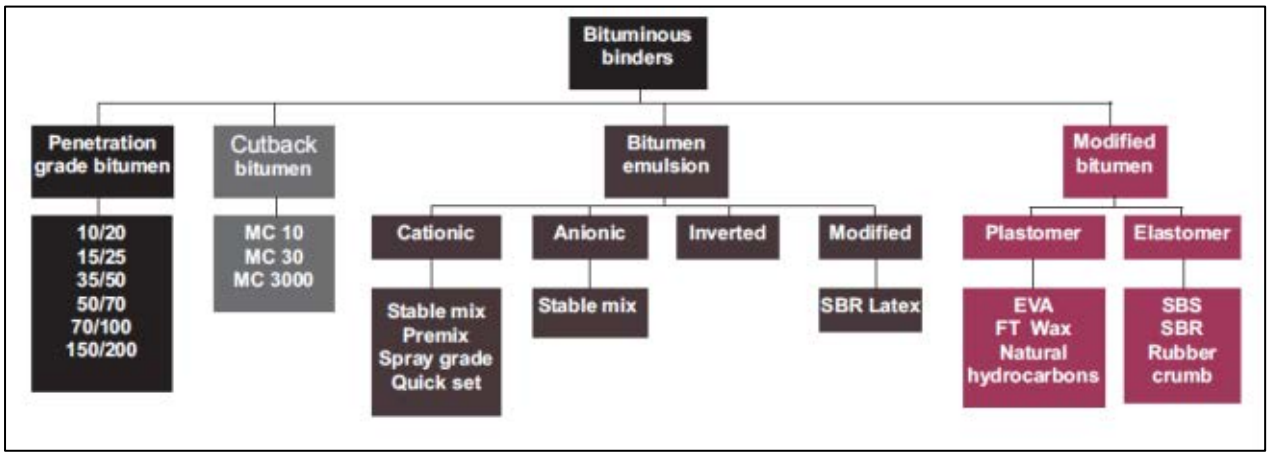

FIGURE 74: CLASSIFICATION OF BITUMINOUS BINDERS

candidate® academy
the road to registration – tower above the rest
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Table of application of bitumen binder types; *South African Pavement Engineering (SAPEM) Manual 9 page 70*:

Class	Category	Grade/Type	Applications
Conventional binders (complying with SANS 4001-BT1)	Penetration grade road bitumen	35/50 pen	▪ High traffic situations where high stiffness is required. ▪ Generally, not appropriate for situations of yielding support layers and low temperatures.
		50/70 pen	▪ Gap, semi-gap, continuous and open-graded asphalt for typical applications in most climatic zones.
		70/100 pen	▪ For improved flexibility of asphalt on more flexible pavements. ▪ Especially appropriate for very thin layers on residential streets where extending the compaction window under conditions of rapid cooling may be a critical consideration.
Modified binders (complying with TGI, 2007)	Elastomer	Styrene-butadiene-rubber (SBR) latex	▪ Improved flexibility and resistance to fracture. ▪ Increased stiffness at elevated temperatures. Lower stiffness at low service temperatures
		Styrene-butadiene-styrene (SBS)	
		Bitumen-rubber	
	Plastomer	Ethyl-vinal-acetate (EVA)	▪ Improved resistance to permanent deformation.
	Natural hydrocarbons	Gilsonyte Durasphalt	▪ Stiffening of the bitumen and hence the stiffness modulus of the asphalt layer.
	Aliphatic synthetic wax	FT Wax	▪ Primarily for lowering the mixing and laying temperatures. ▪ Also has a beneficial effect on the resistance to permanent deformation. ▪ More resistant to fuel spillage than conventional binders.

Refer to *Technical Guide 1 (TG1) The Use of Modified Bituminous Binders in Road Construction* for more information.

17.1.5. MODIFIED BINDERS

Modified binders perform better than normal penetration grade bitumen: in the summer, it is still tough, and does not bleed or disform easily; and in the winter, it is more flexible, and does not become brittle or crack easily.

Warning: Reheating of modified binders, after they have cooled down, causes problems; hot binders clog, which causes emulsions to break. Distributors must be thoroughly flushed with prime or diesel after spraying modified binders. The sieve must also be cleaned. This will prevent blocked nozzles.

Advice: Use a separate distributor to spray a modified binder. A separate tank of about 2 000 litres must be used for flushing purposes only.

If the same distributor is used to do the fog spray, after spraying a modified emulsion, the nozzles will block. The distributor must be thoroughly flushed. The modified binder will stick to the tank and pipes when it cools down, and after being reheated, the thick black lining will come loose and block both the sieve, and the nozzles.

17.1.6. FLUX

Flux (or cutter) is paraffin that is added to modified emulsions to make them more stable, and is usually added in the summer to prevent the emulsion from breaking too soon. No flux emulsion can be specified in the project document and is marked with a ‘t’.

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SC-E1(t) means: S – binder is intended to be used as a surfacing seal

C – binder is an emulsion

E – the main modifier is an elastomer

2 – the binder has a higher softening point than SE-E1

(t) – the use of a fluxing agent or cutter is prohibited

Refer to *Technical Guide 1 (TG1) The Use of Modified Bituminous Binders in Road Construction, chapter 5, page 38.*

17.1.7. SEAL DESIGN

The seal design is based on the Average Least Dimension (ALD) of the aggregate used and the amount of traffic. Climate, surface texture, and penetration into the existing layer is also used to refine the application design. Refer to TRH 3 for details of the seal design.

The following tests are required for the seal design:

1. ALD
2. Texture depth, sand patch
3. Ball penetration.

The seal design is done by the Engineer in the office, but verified and adjusted on site by the Resident Engineer during the trial section.

Note: The seal application rate should be reduced by 5% to 10% on up hills. Steep up hills with slow moving trucks, e.g., no momentum at intersections, the application rate should be reduced by 20%. To be safe, spray the minimum application rate and leave the fog spray contribution. Fog spray could be added later if signs of stripping occur.

Refer to *Colas Handbook 6.6.16* for typical aggregate and binder application rates.

Advice: Double check the seal design with previous projects, or refer to Colas or Tosas guidelines.

Special care should be taken when sealing in winter. Refer to ***paragraph 17.4.3*****.**

17.1.7.1. Conversion Factors

The net cold bitumen application rate of a binder is either calculated, or read from the graph (input: ALD, traffic volume, ball penetration, texture depth, and climate zone). The application rate is adjusted for different binders.

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Example of 14mm/7mm double seal cold net bitumen binder of 2.38ℓ/m², adjusted for different products:

a) Penetration bitumen
b) S-E1, modified binder
c) SC-E1, modified emulsion (winter seal)
d) Rubber seal

First, the fog spray is deducted, then the remaining bitumen is split 50-50, or 55-45, or 60/40.

Fog spray is normally diluted to 50%, and applied at 1.0ℓ/m².

Fog spray cold net bitumen: 1.0ℓ/m² x 0.65 (CAT65) x 50% (diluted) = 0.33ℓ/m²

Remaining cold net bitumen: 2.38 – 0.33 = 2.05ℓ/m²

Split 55/45: 1st spray (tack coat) = 0.55 x 2.05 = 1.13ℓ/m²
Split 55/45: 2nd spray (penetration coat) = 0.45 x 2.05 = 0.92ℓ/m²

Refer to the supplier of bitumen, or to *Sabita Manual 40/TRH 3, November 2020, Table E-10, page 222*, for conversion factors from cold net bitumen to hot bitumen applied at spray temperature.

a) 70/100 Penetration bitumen, conversion factor 1.09
   Tack coat: 1.13 x 1.09 = 1.23ℓ/m²
   Penetration coat: 0.92 x 1.09 = 1.00ℓ/m²
   Fog spray CAT65 diluted 1:1 = 0.33ℓ/m²
b) S-E1, modified binder, conversion factor 1.08
   Tack coat: 1.13 x 1.08 = 1.22ℓ/m²
   Penetration coat: 0.92 x 1.08 = 0.99ℓ/m²
   Fog spray CAT65 diluted 1:1 = 0.33ℓ/m²
c) SC-E1, modified emulsion 70% (winter seal), conversion factor from supplier 1.43 = 1/0.7
   Tack coat: 1.13 x 1.43 = 1.62ℓ/m²
   Penetration coat: 0.92 x 1.43 = 1.32ℓ/m²
   Fog spray CAT65 diluted 1:1 = 0.33ℓ/m²
d) Tack coat rubber seal conversion factors: 1.7 for traffic > 5 000 equivalent light vehicles (elv)
   Example: Elv = 2 000 light vehicles per lane per day + 100 heavy vehicles x 40 (factor heavy to light vehicles) per lane per day = 2 000 + 4 000 = 6 000 elv
   Penetration coat 70/100 pen bitumen conversion factor: 1.09
   Tack coat: 1.13 x 1.7 x 1.07 = 2.05ℓ/m²
   Penetration coat: 0.92 x 1.09 = 1.00ℓ/m²
   Fog spray CAT65 diluted 1:1 = 0.33ℓ/m²

Warning: The minimum application rate for emulsion is 0.5ℓ/m² before it starts to show tram lines, and the maximum application rate is 1.8ℓ/m² before it runs off on a 2% grade, in the case of up-hills or superelevation, the application rate should be reduced to 1.3ℓ/m².

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17.2. Pre-Construction Meeting

It is very important to have a pre-construction meeting before the seal starts to avoid frustrations and delays.

The following parties should attend the meeting:

- Site Agent
- Supervision staff
- Laboratory Manager
- Bitumen supplier
- Aggregate supplier (optional)
- Seal foreman and/or subcontractor.

The following issues need to be discussed:

1. Base repairs required despite previous approval of base layer (damage due to rain, traffic, etc.)
2. Traffic accommodation
3. Approval of aggregate after delivery on site
4. Rejection of aggregate due to limited dust control
5. Bakkie test
6. Good spray operator, only three warnings for overspray
7. Reinforced paper and drip strips at start and end of each spray
8. Fish plates on outside nozzles
9. Flushing of distributor when spraying emulsion, no blocked nozzles
10. Start and end times to allow for enough rolling and brooming
11. Well equipped back chipping team.

These issues should also be addressed in the method statements. For more details, refer to *South African Pavement Engineering Manual 13 Quality Management, Chapter 7.1 Pre-construction meeting, page 58.*

17.3. Trial Sections

A trial section is done to adjust the binder and stone application, and the approval of the plant and method.

17.3.1. DISTRIBUTOR

The distributor must have a valid distribution certificate. These certificates are renewed every year. The distribution is tested by doing a 'bakkie' test. Bitumen is sprayed into buckets which are placed under every three nozzles.

The weight difference (excluding the outer three nozzles) between the buckets must not differ more than:

1. 5% for penetration bitumen binders
2. 7.5% for modified binders
3. 10% for rubber bitumen binders

The COLTO specification is 12% for 100mm strips. Check what the project document specifies.

The distributor must be free from any leaks.

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17.3.2. CHIP SPREADER

The stone application is determined initially by packing the aggregate out on 1m^2. Open and more denser sections are packed. The weight of each section is taken.

A dry run (stone application without binder) is done to confirm the speed and even application of the chip spreader. The gates of the chip spreader are to be adjusted if the cross distribution of stone is not correct. The straightness of the horizontal shaft should also be checked if the distribution varies.

The gate opening of the chip spreader is adjusted during the dry run to ensure that the correct stone application is achieved. 1m^2 canvas is placed and weighed during the dry run. The weight must conform with the desired packing of the stone done by hand at the laboratory.

The conveyor belts of the distributor should be in a good condition. The straightness of the chip spreader shaft should be checked with a 3m straight edge or string line.

Note: The chip spreader gate opening setting must be wider if the aggregate is pre-coated.

17.3.3. TRIAL SECTION

The binder application rate is checked by sealing 200m – 400m sections with different binder applications. The stone application could also be slightly adjusted. The distributor should spray within ±0.06ℓ/m^2 cold net bitumen at 20°C or +/-5% if rubber bitumen is used. Conversion factors from hot binder to cold net bitumen is specified in TRH 3, table 7.3, see seal evaluation for details. These factors are to be confirmed by the suppliers.

S-E1 Adjustment factors (conventional to modified binder)			
Traffic (ELV)	Single seal	Double seal	Split application double seal
< 5 000	1,3	1,1	1,2
5 000 - 20 000	1,2	1,0	1,1
>20 000	1,1	1,0	1,0

S-E2 Adjustment factors (conventional to modified binder)			
Traffic (ELV)	Single seal	Double seal	Split application double seal
<5 000	1,4	1,2	1,3
5 000 - 20 000	1,3	1,1	1,2
>20 000	1,2	1,0	1,1

S-R1 Adjustment factors (conventional to modified binder)			
Traffic (ELV)	Single seal	Double seal	Split application double seal
<5 000	2,0	1,8	-
5 000 - 20 000	1,9	1,7	-
>20 000	1,8	1,6	-

Source: COLTO 4314 Tolerances and finish requirements c) The rate of application, page 4300-15.

Example of adjustment factors for modified binders, *Colas Handbook 6.6.16 page 27*:

The amount of back chipping by hand is indicated by the Resident Engineer to the Contractor.

Advice: Start applying binder at the low end. See how the seal looks and performs, if it is too low it could be adjusted with a higher application of fog spray. Very little could be done if the trial was applied on the high side of the design binder application. The same goes for the stone application rate, start low and increase the application based on how it looks. Extra stone could always be added by back chipping team. Too much stone that is standing upright is difficult to remove.

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17.4. Method Statements

The Contractor must submit a method statement for installing the seal work.

Attention must be given to the following aspects:

1. Testing, and approval of seal aggregate
2. Seal design and tests required
3. Preparation and approval of stockpiles
4. Precoating chips 48 hours before use, 24 hours for modified binders
5. Dust control at stockpile areas and deviation/access roads
6. Traffic accommodation
7. Equipment and production rates
8. Bakkie test
9. Fish plates
10. Overlap and width of first & second binder application
11. Overlap and width of first & second aggregate application
12. Dry run
13. Specifications, application rate and checklist
14. Hold points, base repairs, clean dust free surface
15. Inspection requests, testing and taking samples
16. Duplicate testing of modified binders
17. Back chipping team and hold points
18. Steel wheel roller after first layer of double seal, not for single seal
19. Remove guideline
20. Intersections, and entrance to stockpile areas to be seal last
21. Application adjustment, steep incline, and shadows
22. Cutback bitumen circulated for 20-30 minutes before it is sprayed
23. Chipping in shady areas where stripping is probable
24. Wait till emulsion is breaking (turning black) before applying stone. This will prevent the stone from turning and binder sticking to the tyres of the chip spreader and tipper trucks.

Attention to detail is very important for construction of a good seal.

Tips:

1. Use fish plates for the outside edges of the seal
2. Overlap the centre spray by turning the nozzle
3. Chip over the joint at access roads and where tipper trucks come into the lane that is chipped to prevent binder sticking to the wheels
4. Spray soap liquid regularly on the tyres of the distributor, chip spreader and tipper trucks
5. Remove stones from the centre joint to prevent a double joint
6. Use a drip strip (reinforced paper) and a pull away strip to open the spray bar when the distributor is on speed
7. Heat spray bar when distributor is standing a while in the wind. This will prevent blocked nozzles or tram lines.

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Warning:

1. The distributor is to be properly flushed with prime, after spraying modified binder, and before loading emulsion for fog spray. Sieves should also be cleaned to prevent block nozzles.
2. The distributor truck should be stopped when there is a blocked nozzle.
3. Never add water to hot emulsion, the water turns to stream immediately and expands 17 000 times. It will blow off the lid of the distributor.
4. Do not spray summer grade bitumen when the road temperature is below 25°C.

Tip: Chip spreader must be loaded with chips at the back to prevent it from bouncing.

17.4.1. TRAFFIC ACCOMMODATION

It is important to erect no overtaking signs, road pre-marking, temporary road studs, or delineators on both sides of the road once the seal is placed over the existing road marking.

17.4.2. STRIPPING

The main factors for stripping are:

1. Cold night temperature, e.g., below 10 degrees
2. High speed traffic.

Other factors that cause stripping are:

1. Dusty aggregate
2. Road surface not clean
3. Shadowed areas in the road, e.g., under a bridge, or trees.

Additional rolling is required in shadowed areas. Increased fog spray application will also help to prevent stripping. Precoating of aggregate does help the adhesion of the stone to the binder.

Tip: Stripping could be prevented by the following:

1. Increasing the binder application
2. Slowing down the traffic speed
3. Closing the road during cold night temperatures
4. Additional rolling with PTR in hot weather.

17.4.3. WINTER SEAL

Winter seals are used to limit the risk of stripping. These binders consist of cutback bitumen or emulsion. Spraying with emulsion could cause a problem, as the application rates may become too high, causing the emulsion to flow off of the road. The minimum emulsion application rate is 0.5ℓ/m^2 before it starts to make stripes. The maximum application rate is 1.3ℓ/m^2, depending on how steep the grade is; on flat sections, 1.8ℓ/m^2 has been sprayed successfully. It is best to use 70% emulsion on steeper grades. Fog spray dilution must also be adjusted from 50% dilution to 30% dilution.

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Example: Change of Emulsion:

Case study: Using 70% emulsion instead of 65% emulsion. The application rates are adjusted as follows in order to maintain the same cold bitumen in the design.

Design: Application rate for double seal 14mm/7mm using SC-E1 winter grade 65% emulsion.

Tack coat: 1.75ℓ/m^2 at spray temperature, thus cold net binder is 1.75 x 65% = 1.14ℓ/m^2
Adjusted application rate using 70% emulsion is 1.14 / 70% = 1.63ℓ/m^2

Pen. coat: 1.45ℓ/m^2 at spray temperature, thus cold net binder is 1.45 x 65% = 0.94ℓ/m^2
Adjusted application rate using 70% emulsion is 0.94 / 70% = 1.34ℓ/m^2

Fog spray: 0.90ℓ/m^2 using CAT65 diluted 50/50 (50% water / 50% emulsion).
No adjustments.

Cold net binder is 0.90 x 65% x 50% diluted = 0.29ℓ/m^2

Example: Change of Fog Spray Dilution

Case study: Due to under spray of tack coat and penetration coat, the fog spray application was increased to 1.2ℓ/m^2, using Cat65% emulsion. After the first superelevation, the emulsion ran off the road. The dilution of fog spray was changed from 50/50 to 30/70, and the application rate adjusted in order to maintain the total cold net binder.

Advice: Always work back to the net binder required in the design.

Calculation of 30% dilution when 3 300 litres are left in the distributor:

Cold net bitumen in distributor: 3 300 litres x 65% x 50% dilution = 1 072.5 litres net bitumen.

The distributor, when fully loaded, takes 12 000 litres. The total cold net binder required for 30/70 dilution is 12 000 x 65% emulsion x 70% dilution = 5 460 litres net bitumen.

Total amount of litres of CAT65 to be added: 4 387 / 65% emulsion = 6 750 litres CAT65 emulsion.

CAT65 to be added to the following mark: 3 300 litres + 6 750 litres = 10 050 litres.

Water to be added: 12 000 litres – 10 050 litres = 1 950 litres.

The application rate is adjusted as follows:

Cold net binder: 1.2ℓ/m^2 x 65% x 50% diluted = 0.39ℓ/m^2.

Adjusted 30/70 dilution application using CAT65: 0.39 / 65% emulsion / 70% dilution = 0.86ℓ/m^2.

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Cutback bitumen

Penetration bitumen is mixed with 5% to 10% paraffin to make it softer. This bitumen is used in winter, as it does not easily strip. The problem is that in summer, the seal will easily bleed due to the soft bitumen.

Warning: Wait for the volatiles to evaporate (two weeks during hot weather, or four weeks during cold weather) from cutback bitumen before applying the second seal or fog spray. This will prevent bleeding.

Emulsion

When emulsion is used, the aggregate must not be applied before the emulsion has broken (become black). Chipping before the emulsion breaks will cause the stone to roll in the emulsion, making the top of the stone tacky, and causing pickup on the wheels of the chip spreader and tipper trucks.

Note: It takes two to three days for the binder to 'hold onto' the stone. Roll aggregate with PTR or low speed traffic during warm weather when the binder becomes sticky again; at about 20˚C for penetration and about 25˚C for modified bitumen. When the binder is soft enough, and the aggregate has 'settled', orientate to lay on the flat side for a better bond.

Warning: Do not seal with emulsion when thunderstorms or heavy rain is predicted over the next day or two. Emulsion may take a day or two to break in cloudy weather. The rain could cause the emulsion to wash out if it didn't break, or prevent adhesion of the stone to the binder.

Advice: Stripping will be prevented if the binder has two to three days to 'cleave' onto the stone. Traffic, especially high-speed traffic, must not be allowed on the seal before the aggregate 'sticks' to the binder. Traffic must not be allowed on the seal, especially if there is cold, cloudy, wet weather, or low night temperatures (<5˚C) prevail after sealing, especially in the first three days. The road temperature must be 25˚C before the road is opened for traffic, and the road must be closed for traffic if night temperatures drops 5˚C on the first three nights.

17.5. Supervision

17.5.1. CHECKLIST

The following main points should be checked when sealing:

1. Is the top 50mm of the base 50% below optimum moisture?
2. Is the aggregate too dusty/not washed?
3. Is the road and ambient temperature high enough?
4. Is the temperature of the bitumen correct?
5. Is the joint correct? Is there overlap, or the end nozzle turned?
6. Is the wind causing the nozzles not to overlap?
7. Are any double joints visible?
8. Is the aggregate rolled while the road is still hot?

For a complete seal checklist see ***Appendix J13***.

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Warning: Check the moisture again, especially if it has rained, even though the base has been primed. Hot bitumen on a wet base causes the water to steam and prevents it from adhering to the base.

Tip: If the top 50mm of the base is still about 50% of OMC, a pneumatic tyre roller (PTR) could be used to help dry out the base more quickly. Roll slowly to prevent damaging the primed base.

17.5.2. RECORDS

The following worksheet needs to be completed and signed by both the Consultant and the Contractor. Weather conditions, road temperature, and blocked nozzles are to be recorded. The first and last dip should be visually witnessed by supervision staff. Binder application rates should be calculated. See ***Appendix K5***.

SF213P3

STSA	SEALWORK	WSW1 Rev. 0
Conctract no. C1094	WORKSHEET	Contractor: Baseline

THE REHABILITATION OF MAIN ROAD 531 (KM 76.0 TO KM 92.6, ELANDSBAY)

ROAD NO	MR531	BINDER TYPE	Rubber	STONE SIZE	10mm	SPRAY TYPE	Pen-coat	DATE	21-Apr-17
STONE APPLICATION RATE	125m2/m3	PRECOAT AGENT	Bitucoat	RATE	2.00	l/m2	WEATHER		Clear

FROM km	TO km	LANE	LENGTH m	WIDTH m	AREA m²	TIME	TEMPERATURE °C air	road	binder	BINDER QAUNTITY litres before	after	used	RATE l/m² spray	spec	VISCOSITY Time	cP	SAMPLE Ref no.
24200	25000	LHS	800	3.5	2800	13:45		36	200	15050	9450	5600	2.00	2.00	13:40	3200	RB05
25000	25380	LHS	380	3.5	1330	14:25		38	200	9450	6900	2550	1.92	2.00			
25380	25800	LHS	420	3.7	1554	14:37		36	200	6900	3800	3100	1.99	2.00			
25800	26190	LHS	390	3.7	1443	15:00		34	200	3800	900	2900	2.01	2.00			

TOTAL AREA m²	7127	TOTAL BINDER LITRES	14150	TOTAL STONE m³

PROBLEMS / DELAYS & WEATHER

Plant	
Distrutor	1
Chip spreader	1
Tippers	4
PTR	2
Broom	2

CONTRACTOR

RE / CLERK OF WORKS

17.5.3. QUALITY

Warnings are to be given if the spray operator does not spray within the specified application rates. After three warnings, the operator should be replaced.

Back chipping should be done thoroughly. The joint should be cleaned before spaying adjacent lanes. Double joints should be repaired.

The distributor should be stopped if a nozzle is blocked. If nozzles continue to be blocked, the sieve in the distributor must be cleaned. No spray should be applied if the road temperature falls below the specified limit. Work should be stopped if the wind interferes with the flare of the bitumen when spraying. The distribution bar should be heated before spaying in windy conditions, as the bar cools down, and causes nozzles to block.

The application of stone should be delayed when sealing with emulsion. Wait until the emulsion turns black before chipping. This will help the stone to stick to the binder. If the stones roll in the wet binder and become coated top and bottom, they will pick up on the wheels of the chip spreader and/or tipper trucks.

The chip spreader should follow the distributor immediately after spraying the hot binder. This will help the stone to stick to the binder. This is especially necessary when ambient and road temperatures are falling, or when a breeze cools down the binder after it was sprayed.

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The stone should be applied within two minutes after the distributor has stopped at the end of the pull. Spray sections are to be shortened during windy conditions, or when road temperatures are falling.

The seal should be stopped in the afternoon, to allow enough time for rolling and brooming, so that the stone adheres to the binder. This is critical if the road is opened for traffic at night. It is not critical if the road is closed for the low night temperatures.

Important: Chip loss occurs when the binder cools down during the night and the stone did not stick to the binder. Allow enough time for rolling the chips. Keep traffic speed low to avoid chip loss the next day.

17.6. Tests

17.6.1. AGGREGATE

The grading and the dust content of seal aggregate should be tested regularly, as the stone is delivered to site.

Refer to *South African Pavement Engineering Manual 13 Quality Management, Table 18* for the testing frequency of seal aggregate.

17.6.2. PENETRATION BITUMEN

Penetration bitumen is tested at the refinery. Penetration tests should be done once for each seal period or bulk delivery.

Refer to *South African Pavement Engineering Manual 13 Quality Management, Table 21* for the testing of conventional binders.

17.6.3. MODIFIED BINDERS

Refer to *South African Pavement Engineering Manual 13 Quality Management, Table 13* for the testing frequency modified binders.

The most important test on a modified binder is the softening point. *Technical Guide 1: The Use of Modified Bituminous Binders in Road Construction in Tables 5 And 6, Page 33 – 34* indicate tests to be done for modified binders and modified emulsions.

The residual binder for emulsions should be tested daily.

The softening point for modified binders should be tested daily.

The viscosity of rubber bitumen should be checked daily before the first spray and throughout the day.

Important: The properties of modified binder and rubber bitumen change when the binder is kept at high temperatures.

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The storage temperatures of modified binders must be monitored.

17.6.4. EMULSIONS

The binder content of the emulsion should be tested daily or for each distributor load.

17.6.5. BITUMEN RUBBER

The viscosity of the bitumen rubber should be checked before each spray. Normal bitumen rubber will dissolve and become normal bitumen if kept at high temperature for long. Bitumen rubber should be sprayed within four hours after mixing the rubber crumbs with the bitumen. This period is extended when extender oils are used. Contact the supplier for information.

Tests done on rubber bitumen include the following:

1. Grading of the rubber crumbs
2. Viscosity 2000Pa.s – 4000Pa.s
3. Ring & ball 55°C - 62°C
4. Resilience
    a) After 5min > 70%
    b) After 1 hour > 70%
    c) After 4 hours
5. Flow 15mm – 70mm

Refer to *South African Pavement Engineering Manual 13 Quality Management, Table 14* for the testing frequency rubber bitumen.

17.7. Evaluation

The total over/under spray (first spray plus second spray and fog spray) must be calculated and compared to the total net bitumen design. The tolerances and payment must be applied to the total spray application.

17.7.1. OVER/UNDER SPRAY

Extraction of 14mm/7mm double seal design:

Double seal design: 14mm/7mm	Spay 1	Spray 2	Spray 3
Spray (ℓ/m^2)	1.23	1.02	0.9
Binder type	S-E1	S-E1	CAT 65 diluted 1:1
Required cold net bitumen (ℓ/m^2)	1.14	0.94	0.3
Spray temperature (°C)	170 – 180	170 – 180	65
Recommended Rate (ℓ/m^2)	1.23	1.02	0.9

The S-E1 modified binder conversion from cold nett bitumen to hot bitumen is 1.08.

Tack coat 1.14 x 1.08 = 1.23 and pen coat 0.94 x 1.08 = 1.02.
Emulsion: CAT 65 (65% emulsion 35% water) to be diluted 50/50.
Total net binder from fog spray is 0.9ℓ/m^2 x 0.65% x 50% = 0.29ℓ/m^2.

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The tolerance for cold net binder is 0.06ℓ/m^2 (COLTO 4314 c)

Spray	Design hot applied	Actual hot applied	Difference	Actual cold net	Design cold net
1st Tack coat	1.23	1.31	+0.08	1.21	1.14
2nd Penetration coat	1.02	0.99	-0.03	0.92	0.94
3rd Fog spray	0.9	0.81	-0.09	0.26	0.29
Total				2.39	2.37
Min / Max ±0.06					2.31 – 2.43

The cold net bitumen is calculated as follows:

Tack coat 1.31 / 1.08 = 1.21 and pen coat 0.99 / 1.08 = 0.92. Fog spray is 1.81 x 0.65 x 0.5 = 0.26.

Although the tack coat (+0.08) and fog spray (-0.09) were outside the specified tolerance (±0.06), the total net cold binder (2.39ℓ/m^2) was within specification (2.37 ± 0.06).

The fog spray could always be adjusted up or down when the tack coat and/or penetration coat was over/under sprayed.

17.7.2. VISUAL INSPECTION

The spreading of aggregate after the first spray should be checked. Open spaces, the size of old 50c coins or larger, should be filled with stone. Back chipping should be approved before the second spray could be applied. Back chipping of the second spray should be approved before the final fog spray is applied.

Double joints should be fixed by kicking off excess stones before applying the second spray or fog spray.

Any damage to the seal, blocked nozzles, or tramlines to be fixed.

17.7.3. TEST RESULTS

Any binder that fails should be referred to the engineer for evaluation and remedial action. Duplicate samples should be tested by a third party.

17.7.4. ACCEPTANCE

After all the criteria has been met, the Resident Engineer can sign off and comment on the seal that was submitted for approval. The package is then stapled together, and the layer works register is signed.

The staff member responsible for supervision of the layer signs off and comments on the visuals, materials, and application rate of the binder and aggregate of the seal.

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The following forms are signed off and form part of the package that is stapled together:

1. Test request from Contractor
2. Tests to be done issued to the laboratory manager
3. Laboratory test results submitted by the laboratory manager
4. Checklist of supervision staff
5. Worksheet of supervision staff
6. Test results
7. Final comment on test request by Resident Engineer
8. Signed off test register

The Resident Engineer makes a final decision and will write one of the following comments:

- Accepted
- Rejected
- Reduce payment
- Re-test
- Remedial actions required
- Monitor

The seal can now be paid according to findings of the Resident Engineer.

17.8. Payment

The rate in the Bill of Quantities (BoQ) is based on a nominal binder and stone application rate. The actual rate used on site varies from this rate and is paid under aggregate and binder variations. Seals are paid per square meter. Variance of aggregate and bitumen is paid per cubic meter and litres, respectively.

Note: Variation of binder and aggregate could be negative.

17.8.1. AGGREGATE VARIATION

Payment of variation in aggregate application rates:

As an example, if the total area sealed is 3690m^2, and the actual aggregate application is 135m^2/m^3, but the tendered nominal application rate is 140m^2/m^3, then the aggregate variation will be 3690/135 – 3690/140 = 0.98m^3.

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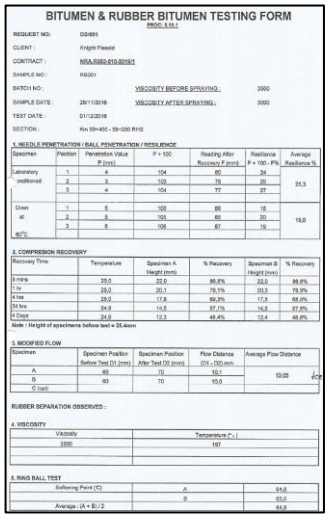
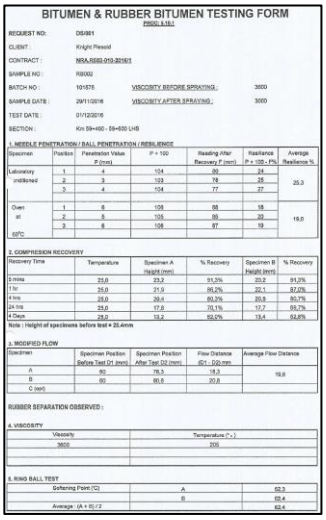
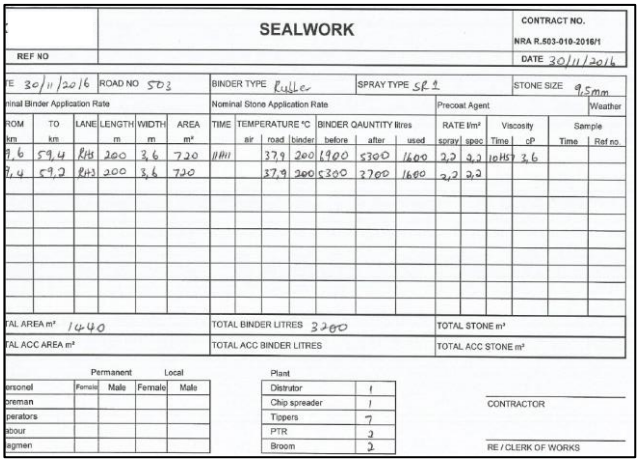
Example of package to be signed off and filed:







TRH 3 Table 7.3:

Type of binder	Conversion factor (check with manufacturer)	Spray temp. (°C)	Storage temp. (°C)
Cut back bitumen			
MC 3000	1.19 – 1.27	130 – 155	100
MC 70	1.63 – 1.72	60 – 80	Ambient
MC 30	1.88 – 1.99	45 – 65	Ambient
Penetration grade bitumen			
150/200 pen	1.09	145 – 185	115
80 /100 pen	1.09	160 – 200	125
Polymer modified bitumen			
S-E1	1.08	165 – 190	150
S-E2	1.08	165 – 190	150
Bitumen rubber (S-R1)	1.07	195 – 205	-
Bitumen emulsions			
60% emulsion	1.68	60	Ambient
65% emulsion	1.55	60	Ambient
70% emulsion	1.44	70	Ambient

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17.8.2. BINDER VARIATION HOT APPLIED

Calculation of binder variation:

Nominal application rate: 1.1ℓ/m^2 hot applied modified binder. Design (actual) application rate: 1.2ℓ/m^2.

14mm seal: 500m x 3.4m = 1 700m^2, dip before 7 500 litres, dip after 5 300 litres.

Litres used: 7 500 – 5 300 = 2 200 litres, application rate: 2 200 / 1 700 = 1.29ℓ/m^2.

Tolerance for overspray is 0.06ℓ/m^2, thus max payment for binder variation is 1.20 (specified) + 0.06 (tolerance) = 1.26ℓ/m^2.

Payment for bitumen variation = 1.26 – 1.1 (nominal) x 1 700 (area) = 272 litres.

17.8.3. BITUMEN VARIATION AND RISE AND FALL OF RUBBER BITUMEN

Calculation of binder variation and the rise and fall of 13.2mm rubber seal (Actual spray rates was within the specified 5% tolerance):

Nominal rubber hot binder application rate is 2.0ℓ/m^2. The road length is 30 230m, the width is 12.4m.
Actual litres rubber bitumen used was 768 450 litres, actual overall spray rate was 2.05ℓ/m^2.
Specified design application rate was 2.10ℓ/m^2.
The base rate for bitumen is R4 550/ton; the current rate is R4 537.47/ton.
20% rubber crumbs are added for the bitumen rubber. 2% extender oil is added.

<u>Binder variation hot:</u>
Variation = Actual application - Nominal application
Actual application – area x 2.0ℓ/m^2
768 450ℓ – (30 230m x 12.4m x 2.0ℓ/m^2) = 18 746 litres.

<u>Rise and fall</u>
768 450 litres / 1 000ℓ/m^3 x 1.029ton/m^3 x 78% (bitumen because 20% is rubber and 2% extender oil) / 1.08 (hot/cold factor) x (R4 537.47 – R4 550) = -R7 155.71

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18. SLURRY

18.1. Designs

The slurry design is done to determine the amount of emulsion to be added to the aggregate. Too much emulsion, and slurry will bleed. Too little emulsion, and the slurry will ravel.

Tip: The correct amount of emulsion could be determined by the colour of the slurry. Grey colour shows too little emulsion, black colour shows too much emulsion, a creamy brown indicates the correct amount of emulsion.

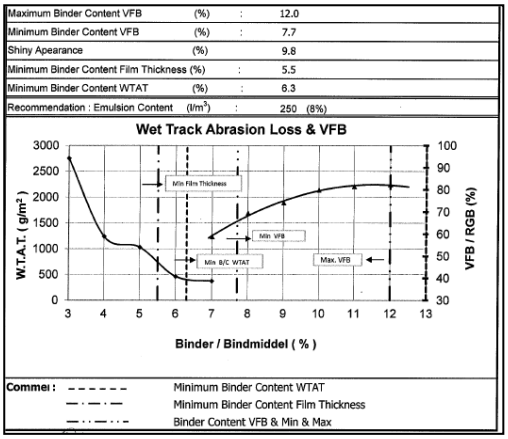

FIGURE 75: SLURRY DESIGN

An official slurry design, and special tests done by main laboratories, are required for big projects. The net binder content should be between 6.5% to 8.0% or 180 litres to 240 litres emulsion per cubic meter.

Slurry briquettes are made by adding different amounts of emulsion to the aggregate. Cement content remains at 1%. Abrasion tests are done on the briquettes. The colour and abrasion tests indicate the optimum amount of emulsion to be used per cubic meter.

18.2. Materials

Refer to *South African Pavement Engineering Manual 13 Quality Management, Table 26* for the testing water to be used for slurry.

The grading of the slurry should be approved. Refer to *COLTO Table 4302/11.*

Stable grade emulsion is used for slurry.

Other important tests:

1. Water
    a) Acidity pH
    b) Conductivity
    c) Minerals
2. Soluble salts

Warning: Smooth rounded natural sand causes slurry to ravel. Aggregates without fractured faces do not interlock.

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18.3. Method Statements

The mixing and application of the slurry must be stated and approved in the method statement.

Mixing methods:

1. Small concrete mixer for small quantities
2. Slurry truck, for medium projects
3. Batch mixing plant for medium to large projects

A slurry truck is required for thick slurry applications using a box.

Texture and cape seal slurries are applied by hand with squeegees.

The surface should be pre-wet before the application of the slurry. It breaks the surface tension and helps the slurry penetrate the seal.

Important: The water added to the slurry must be closely monitored.

Too much water and the slurry will segregate, too little water and the slurry will be difficult to go into the seal aggregate voids, not workable.

Warning: It is important to erect no overtaking signs, road pre-marking, temporary road studs or delineators on both sides of the road once the slurry is placed over the existing road marking.

Caution: The mix proportions of the emulsion to crusher dust must be adjusted after it rains; the fine material could bulk up to 30%. Refer to ***paragraph 19.5.2***.

18.4. Checklist

The main points to check when applying slurry are:

1. Is the right amount of emulsion used?
2. Check colour and consistency of the slurry.
3. Pre-wet the surface to cool down and break surface tension.
4. Use a guide rope at edges of the road.
5. Monitor the thickness of the slurry.

For a complete slurry checklist see ***Appendix J14***.

18.5. Worksheet

It is important to complete the worksheet and determine the thickness of the slurry. The following worksheet needs to be completed and signed by both the Consultant and the Contractor.

See ***Appendix K6***.

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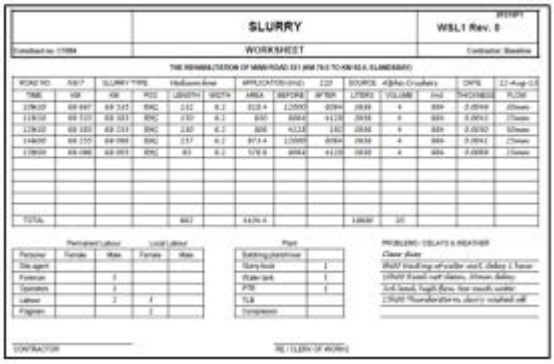

SLURRY

WSL1 Rev. 0

WORKSHEET

Refer to *Table 23 in SAPEM Chapter 13: Quality Management* for thickness of slurry:

Conventional slurry	Thickness	Micro surfacing	Thickness
Texture slurry	1 – 3 mm	Medium overlay	6 – 8 mm
Thin overlay	4 – 6 mm	Thick overlay	8 – 15 mm
Medium overlay	6 – 8 mm	Shape correction	8 – 15 mm
Thick overlay	8 – 12 mm	Rut filling	8 – 30 mm

If slurry applications are not within these limits, the method of how it is applied or calculated must be investigated.

18.6. Tests

The binder content and the flow of the slurry are tested.

The flow test is done on site when a new batch of slurry starts. The flow test indicates if the slurry is workable or segregated. The flow should be 30mm to 40mm for texture slurry. Below 30mm, the slurry is difficult to work in between the seal stone. Above 40mm the slurry will start to segregate, as it is too watery.

FIGURE 76: SLURRY FLOW TEST

18.7. Evaluation

18.7.1. VISUAL INSPECTION

Visual inspections are done to approve the texture and application of the slurry. The slurry must be applied so that just the tops of the seal stones are visible. The texture must be uniform, all voids between the stones must be filled.

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Problems: Slurry could be washed off by rain.
The slurry could break too soon or in the mixing trucks on hot days.
PTR could roll slurry before it has set, and thus pick up the slurry on the tyres.
If the slurry is too rich (colour dark brown / black) it will bleed. If the binder in the slurry is too little (light grey) it will ravel.

18.7.2. TESTS

The binder content of the slurry must be within the specified tolerance of 0.06 litre/m^2 cold net bitumen (20 °C) from the target binder. Refer to *COLTO 4314 c*.

Example of tolerance of slurry:

Target binder: 7.2%. Actual binder tested in the laboratory: 7.8%. BRD of the slurry 2 300kg/m^3. Average thickness is 3.5mm.
Target cold net binder ℓ/m^2: 2 300kg/m^3 x 7.2% x 0.0035m = 0.497ℓ/m^2.
Tolerance ± 0.06ℓ/m^2 thus 0.437ℓ/m^2 0.557ℓ/m^2.
Actual binder used: 2 300kg/m^3 x 7.8% x 0.0035m = 0.628ℓ/m^2, thus is > 0.557ℓ/m^2, thus rejected.

18.7.3. ACCEPTANCE

Slurry must be visually accepted. Coarse sections or rain damage to be repaired with slurry.

The thickness of the slurry should be monitored.

18.8. Payment

Slurry is paid in cubic meter. Ensure that payment is done for slurry that is on the road, excluding wastage.

The slurry truck should be measured. The level of the aggregate is to be taken at the end of the day's work. The volume of aggregate used should be calculated.

Payment Item		Description	Unit	Rate	Quantity	Amount	
48.03		(f) Application of slurry for texture improvement with natural or crusher sand, applied by hand (Fine to medium grade, fine slurry as per Table B4302/11)	m^3	R 4 200.00	350	R 14 700 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
30/08/20	8	Km 0 to km 12,4 L&R 27 Jul – 25 Aug, (SA031 – SA059)		164.3	164.3		

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Summary of texture slurry quantities MR540:

REQ. No.	Date	L/RHS	FROM SV	TO SV	Length	Width	m^3	Thickness (mm)	EMULSION (Lt)	BINDER (%)	FLOW (mm)
SA031	27/07/2020	RHS	1500	2200	700	3.4	5.28	2.2	1200	7.20	40mm
SA032	28/07/2020	LHS	990	2200	1210	3.4	8.8	2.1	2000	6.10	40mm
SA037	29/07/2020	RHS	64	1500	1436	3.4	9.24	1.9	2100	5.80	40mm
SA038	30/07/2020	LHS	64	990	926	3.4	5.28	1.7	1200	6.10	40mm
SA039	31/07/2020	LHS	2200	3500	1300	3.4	10.56	2.4	2500	6.10	40mm
SA040	01/08/2020	RHS	2200	3670	1470	3.4	10.56	2.1	2500	6.00	40mm
SA041	03/08/2020	LHS	3500	4954	1454	3.4	10.56	2.1	2500	6.00	40mm
SA042	04/08/2020	RHS	3670	4800	1130	3.4	8.8	2.3	2050	6.10	40mm
SA043	05/08/2020	LHS	4954	6180	1226	3.4	10.56	2.5	2500	6.10	40mm
SA046	06/08/2020	RHS	4800	6226	1426	3.4	10.56	2.2	2500	5.70	40mm
SA047	07/08/2020	LHS	6180	7352	1172	3.4	9.68	2.4	2300	5.80	40mm
SA047	13/08/2020	RHS	6226	7085	859	3.4	5.28	1.8	1250	5.80	40mm
SA051	14/08/2020	LHS	7352	8500	1148	3.4	10.56	2.7	2500	5.90	40mm
SA052	17/08/2020	RI-IS	7085	7900	815	3.4	5.28	1.9	1250	6.30	40mm
SA053	18/08/2020	RHS	7900	8500	600	3.4	5.28	2.6	1250	6.15	40mm
SA054	19/08/2020	LHS	8500	9162	662	3.4	5.28	2.3	1250	5.90	40mm
SA055	20/08/2020	RHS	8500	9327	827	3.4	6.16	2.2	1450	6.00	40mm
SA056	21/08/2020	RHS	9327	10400	1073	3.4	7.92	2.2	1900	5.90	40mm
SA057	22/08/2020	LHS	9162	9954	792	3.4	5.28	2.0	1250	6.00	40mm
SA058	24/08/2020	LHS	9954	11000	1046	3.4	8.14	2.3	1900	6.00	40mm
SA059	25/08/2020	RHS	10400	11263	863	3.4	5.28	1.8	1350	6.00	40mm
TOTAL					**22135**		**164.3**	**2.2**	**38700**	**7.20**	

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19. ASPHALT

19.1. Asphalt Plants

The location of new mobile plants should be discussed with the Engineer. The access road must be safe with enough sight distance.

Tip: The laboratory should be placed close to the asphalt plant for production control by the Contractor. Results are quickly available and limited reheating is required for hitting marshal briquettes.

Warning: The moisture of the crusher dust stockpile is to be monitored, and the plant mix adjusted. After the rain, the sand/dust bulks and the binder content become too high, as water instead of dust is weighed into the asphalt mix.

The supplier must submit a valid weigh bridge certificate for the asphalt plant.

The asphalt plant must comply to the environmental regulations regarding dust control.

19.2. Material Approval

The aggregate to be used for the asphalt must be tested and submitted for approval. Where bitumen rubber is specified, rubber crumbs and extender oil must be tested and approved. See *COLTO Table 4202/1* and *4202/2.*

19.2.1. AGGREGATE

The aggregate for the asphalt must be tested and submitted for approval. The criteria to be met:

1. Hardness: ACV & 10% FACT, see table below
2. Flakiness, see table below
3. PSV min 50, except gap graded surfacing min 45
4. Adhesion min 75%
5. Absorption; coarse aggregate max 1%, fine aggregate max 1.5%
6. Sand equivalent min 50, natural sands min 30
7. Grading; see *COLTO table 4202/6 to 4202/10.*

Source: COTO Chapter 9: Asphalt Layers, Part A9.1.5.4.a) Aggregate properties, page 9-6 to 9-7.

Nominal size of aggregate (mm)	Maximum flakiness index %			
	Surfacing aggregate		Rolled-in chips (all grades)	Base*
	Grade 1	Grade 2		
21.0	25	30	20	35
12.2	25	30	20	35
9.5	30	35		
6.7	30	35		

* at least one face fractured for aggregate > 4.75mm

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Resistance to crushing	Base and surfacing	Surfacing	Rolled-in chips, open graded surfacing, stone mastic
ACV	Max 25	Max 25	Max 21
10% FACT	Min 160kN	Min 160kN	Min 210kN
10% FACT wet dry ratio	Min 75%		

Refer to *South African Pavement Engineering Manual 13 Quality Management for the testing frequency, table 10, 11 and 12*.

Other important tests:

1. Hardness
    a) Ethaline Glycol
    b) Methanol Blue
2. Soluble salts

Warning: Although crushed stone is a durable material, fault lines with smectites, etc. may exist in the quarry. The quarry should be inspected. Swell tests must be done on any blast furnace slags. Smooth rounded natural sand causes asphalt to ravel. Aggregates without fractured faces do not interlock.

19.3. Designs

The asphalt design is submitted on the D3 design form by the Contractor, indicating the target binder content. The asphalt must meet the specified criteria. The mix proportions of the aggregate and the binder content are adjusted to meet these specifications. In the performance-based asphalt mix designs, the target binder is determined to achieve 4% voids in the mix. Refer to *Sabita Manual 35 Design and Use of Asphalt*. The binder content and the grading of the asphalt, especially the 0,075mm sieve, play an important role in the mix design.

Procedure for approval of asphalt mix designs:

1. D3 form submitted and check to meet specifications
2. Asphalt plant trial mix done at different binder contents e.g., 4.5%, 5.0%, and 5.5%
3. Trial section done on the road to verify that asphalt density could be achieved with asphalt mix design and plant.

The target binder is then formalised on the D3 asphalt design form. The Engineer is to approve asphalt mix design after the client has approved the proposed mix design. The target binder for the asphalt mix design should be recorded on the D3 form, and confirmed in a site instruction or letter. See specifications of asphalt properties.

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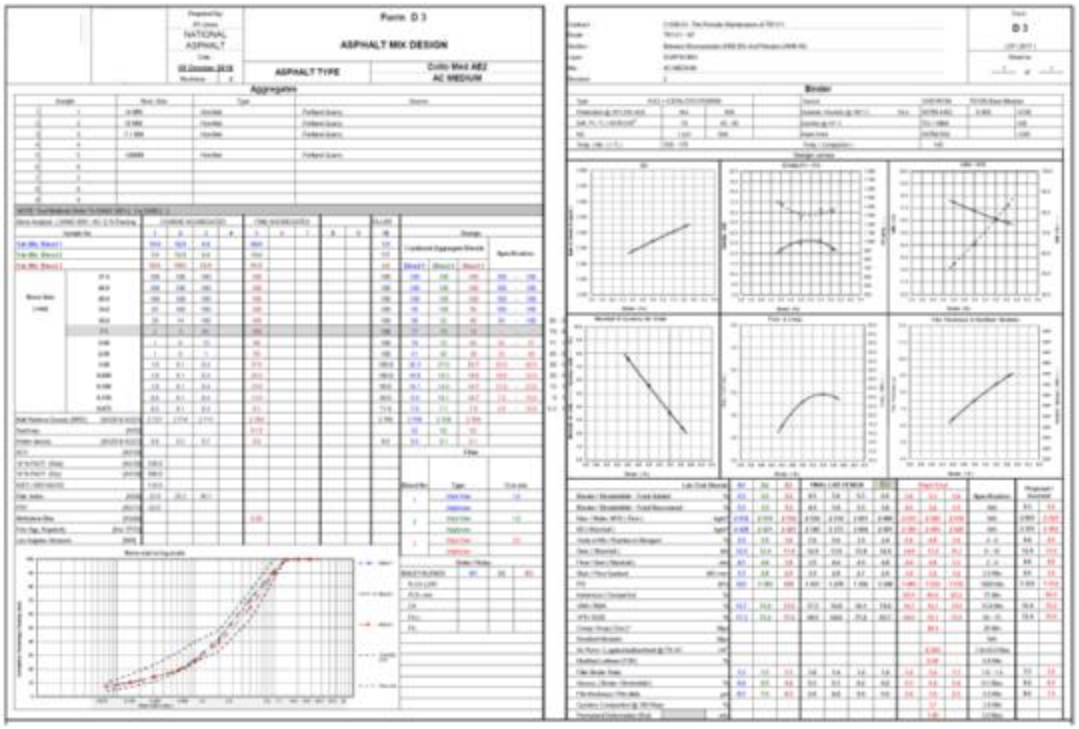
Refer to *Sabita Manual 35 Design and Use of Asphalt* for details of performance-based asphalt certification for asphalt suppliers.



19.4. Trial Sections

The aggregate mix proportions and the results on the D3 design form are to be verified with actual results obtained from the plant.

19.4.1. PLANT TRIALS

The plant is to produce asphalt at different binder contents to see what influence it has on the following properties: voids, stability, bulk relative density, flow, creep, film thickness, etc. These parameters indicate the performance of the asphalt. Asphalt could deform (rut), bleed, ravel or be very porous. Parameters for asphalt mix are detailed in *COLTO Table 4203/1.*

The asphalt plant trial mix is done at different binder contents e.g., 4.5%, 5.0%, and 5.5%.

The D3 form is updated with the actual results and a target binder content is suggested.

If any of the asphalt parameters are not met, the aggregate mix proportions need to be changed and a new mix design proposed. This may take a while when setting up a new asphalt plant. Established asphalt plants have established these mix proportions from previous trials.

19.4.2. TRIAL SECTION ON THE ROAD

After the theoretical asphalt design mix design is verified with plant trials, an asphalt trial section is done on the road. This is done to verify that the asphalt density could be achieved with asphalt, the compacting equipment, and sequence of rollers.

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The asphalt properties and density are tested. The method statement must be adjusted to ensure the specified density and riding quality are met. After a successful trial section, the target binder content is determined. The asphalt design D3 form is then signed and approved.

Special tests could be done to determine the long-life performance of asphalt; see ***paragraph 19.7***.

19.5. Technical Discussions and Method Statements

19.5.1. TECHNICAL DISCUSSION

Technical Discussion Agenda:

1. Approval of asphalt mix designs, plant trial, and site trial
2. Weigh bridge calibration
3. Method statement
4. Equipment, levelling beams and production rates
5. Canvas on trucks, PTR cleaning wheels with diesel when cold
6. Tack coat application, protection of traffic
7. Specifications and checklist
8. Hold points
9. Continuous paving and riding quality, IRI, coarse sections, and bumps
10. Cutting joints
11. Inspection requests, testing and taking samples
12. Duplicate testing, and split samples, avoid reheating for marshal briquettes
13. Testing of modified binders
14. Coring and asphalt thickness and payment
15. Backfilling of core holes.

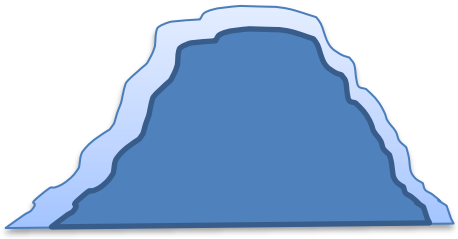
FIGURE 77: PLANT

19.5.2. MOISTURE OF FINE MATERIAL

The volume of fine material, crusher dust, and sand expand up to 30% when it rains. The binder content on the asphalt mixing plant must be adjusted after the rain to ensure that too much binder is not added to the bulked fine material. See example below.

Example:

Bitumen added on 1m³ dry material is 4.5%. After the rain, the material bulks 20% in volume. With no adjustment, the same bitumen is added to the volume, but 20% is water and 80% fine material. The actual binder added is 4.5% / 0.8 = 5.6% binder.



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19.5.3. METHOD STATEMENT

The Contractor must submit a method statement for paving asphalt. The method and the plant used must be approved by the Engineer.

The following points should be addressed in the asphalt method statement:

1. Pave at a **constant speed**, selected to suit the compaction effort.
2. Feed the paver with a **constant supply of material**, to reduce start/stop activities to an absolute minimum.
3. Before paving, **clean the screed**; before paving, check for wear and then heat to suit the mix type.
4. **Tow points**, which control how the paver moves up and down, are correctly set for the required mat thickness.
5. Paving **always starts on starter blocks** under the screed.
6. **Paving lines are marked out** each side of the paver for guidance.
7. **Extension augers** are attached to suit the paving width.
8. **Forward movement only commences** once auger boxes are filled over their full width.
9. A **constant head of asphalt** across the entire width of the screed is maintained.
10. The **hopper is not emptied between loads.** The new load is added to the hopper to heat up the remaining asphalt from the previous load.
11. **Tipping of trucks is well controlled** to avoid spillage in front of the paver.
12. **Paving thickness** is checked regularly by calculations and with a dip rod. Adjustments are made gradually and evenly.
13. **Excessive manual adjustment** of the tow points is not allowed.
14. Frequently check the **mat finish between the paver and the rollers** with a straight-edge and visually, to identify any problems.
15. **Avoid walking on the unrolled mat.**
16. **Handwork is limited** to areas inaccessible to the paver, or for correcting deficiencies.

Source: South African Pavement Engineering Manual Chapter 12: Construction Equipment and Method Guidelines, Section 3: Construction Process Guidelines, Part 3.11.1.3: Good paving practices, page 117.

19.5.4. TRAFFIC ACCOMMODATION

It is important to erect no-overtaking signs, road pre-marking, temporary road studs or delineators on both sides of the road once the asphalt is placed over the existing road marking.

19.6. Supervision

19.6.1. CHECKLIST

The following main points should be checked when paving asphalt:

1. Is the surface clean, without dust, before applying the tack coat?
2. Is the correct asphalt mix used?
3. Is the temperature of the asphalt correct?
4. Is the thickness of the asphalt correct?
5. Is the asphalt segregating?
6. Are the tamping bars working?
7. Is the water on steel wheel roller working?
8. Is the asphalt still hot while it is being compacted?
9. Did the laboratory come to take samples?

For a complete checklist see ***Appendix J15***.

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19.6.2. WORKSHEET

The following worksheet needs to be completed and signed by both the Consultant and the Contractor.

WESTERN CAPE PROVINCIAL ADMINISTRATION — ROADS AND TRAFFIC ADMINISTRATION BRANCH

Reporting - Progress Log - Asphalt Layers
Base; Wearing Course " (Single / Top / Bottom ")

R - LOG - ASP1 - E

Contract No: C1090.01		Route / Street: TR11/1 (N7)		Contractor: RMSC			Lot No:	3
Asphalt Supplier: National Asphalt		Paving Contractor: Roadmac Surfacing Cape		Asphalt Type:		Cotto BTB	Date Placed:	19/Feb/19

Carriageway		SB	SB	SB	SB	SB	SB	SB	SB				
Lane		SL	SL	SL	SL	SL	SL	SL	SL				
Truck No.		FLD766MP	JRN425MP	JKD377MP	FLD766MP	JRN425MP	JKD377MP	FPW334	FLD766MP				
Consignment No.		22999	23000	23001	23002	23003	23004	23005	23006				
Truck Load (Ton)		17.14	16.26	16.04	14.88	14.5	16.16	16.78	13.46				
Cumulative Tonnage		17.14	33.4	49.44	64.32	78.82	94.98	111.76	125.22				
Arrived at Site (Time)		00:00	00:00	00:10	01:12	01:12	01:20	01:56	02:48				
Load Temp. in Truck		164	168	156	168	166	150	162	162				
Placing Time	Start	00:05	00:12	00:20	01:15	01:20	01:31	02:02	03:02				
	End	00:10	00:17	00:25	01:20	01:26	01:39	02:12	03:28				
Section Placed	Start (SV)	7772.2	7746.7	7722.4	7698.7	7672.2	7647.2	7624.2	7843.3				
	End (SV)	7746.7	7722.4	7698.7	7672.2	7647.2	7624.2	7594	7834.5				
	Length (m)	25.5	24.3	23.7	26.5	25	23	30.2	8.8				
	Cum. L (m)	25.5	49.8	73.5	100	125	148	178.2	8.8				
	Width (m)	3.8	3.8	3.8	3.8	3.8	3.8	2	3.62				
	Area (m^2)	96.9	92.34	90.06	100.7	95	87.4	60.4	31.812				
	Thick (mm)	75	75	76	63	65	79	77	180				86
	Tons							9.23					
Temperature	Truck	164	168	156	168	166	164	162	162	162	162		
	Hopper	150	158	148	148	132	150	156	140	140	140		
	Layer												
Last truck waste											0		
GVM													
Total Mass													
Thickness													

Remarks:

See ***Appendix K7*** for an example.

The worksheet is used to calculate the average asphalt thickness during the operation. It is important to record the arrival time and the temperature of the asphalt. Asphalt below 120°C becomes difficult to compact. Any delays or breakdowns must be recorded.

Calculation of asphalt thickness: Thickness = tons / Bulk Relative Density (BRD) / area

Example: Truck JNR425MP; Thickness = 15.26ton / 2.35t/m^3 /92.34m^2 = 0.0749m

Example of calculation of asphalt waste:

Asphalt waste of truck FLD766MP:

- Average thickness of the day (truck 1 – 7): 73mm
- Area: 8.8m x 3.62m = 31.812m^2
- Tons paved = volume x BRD
- Tons used = 31.812m^2 x 0.073m x 2.35 tons/m^3 = 5.46 tons
- Waste: tons delivered – tons paved
- Waste = 12.46 tons – 5.46 tons = 8.0 tons

19.7. Tests

Samples are taken to do the grading and binder content. Samples of asphalt briquettes to be tested with the Marshall hammer test must be tested at 145°C. Cores are drilled to check the density of the asphalt.

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Refer to *South African Pavement Engineering Manual 13 Quality Management, Table 10* for the testing frequency of asphalt aggregates, and *Table 15* for the testing frequency asphalt.

Refer to *South African Pavement Engineering Manual 13 Quality Management* for the testing frequency of the following:

- Table 10: Aggregates
- Table 11: Reclaimed asphalt
- Table 12: Fillers
- Table 13: Hot polymer modified binders
- Table 14: Bitumen rubber
- Table 15: Asphalt mix

Sampling guidance for smaller projects:

1. Grading and binder content, the greater of #4 samples per lot or one per 50 tons
2. Marshall briquettes, min #1, one per 100 tons
3. Core densities, min #4, one per 50m – 100m.

Important: Triplicate samples are to be taken and tested by independent laboratories at the beginning of the asphalt. Wrongly tested asphalt could lead to big claims later.

The following specialised tests could be done to determine the performance of the asphalt:

1. Gyratory testing
2. Rut test

19.8. Evaluation

The following asphalt properties are statistically evaluated:

1. Density
2. Binder content
3. Voids
4. Grading
5. Thickness

Test results must be checked for any outliers. The outliers are omitted from the lot. Visual inspections are required at outlier positions. The data is then statistically analysed and approved, rejected, or conditionally accepted with reduced payment. Conditional acceptance is granted only with permission from the Engineer. The Client may ask for a performance guarantee before accepting below standard results.

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Results that are not statistically analysed are:

Test	Unit	Specification
Grading		
Voids in mineral aggregate (VIM)	%	> 15
Voids filled with bitumen	%	65 – 78
Stability	kN	8 – 15
Flow	Mm	2 – 6
Stability/Flow ratio		> 2.5
Bitumen absorption	%	< 0.5
Film thickness	M	5.5 – 8.0
ITS average	kPa	1000 – 1500

These results are not used to reject the asphalt layer, but rather to indicate that there might be a problem with the performance of the asphalt, e.g., difficult to compact, rutting, or bleeding. The Contractor/Supplier must be made aware if results are borderline or not to specification. These areas must be monitored. If one or more properties continue to be too low or high, a meeting should be held with the supplier to resolve the problem. Special tests may be required to ensure long-life performance of the asphalt, see special tests in ***paragraph 19.7*****.**

Danger: The test results must not be blindly accepted as correct, and must be analysed. What is on paper must resemble what was seen on site.

Questions to ask before accepting or rejecting asphalt: Was the asphalt compacted while still hot? How do the asphalt cores look when looking at the voids? How does the texture of the asphalt look on site, dense or coarse?

Important: Rejecting asphalt without proper understanding of why it failed is not advisable. Respect from the Contractor is earned by thorough investigation before decisions are made to reject work.

Refer to *South African Pavement Engineering Manual 13 Quality Management* for the evaluation and assessment:

- 6.7 Interpretation of Laboratory Test Results of Acceptance Control, page 55
- 6.8 Assessment of Non-Conforming Work, page 57.

See ***Appendix B8*** for a register, and ***Appendix E8*** for an inspection request. The asphalt evaluation spreadsheet as demonstrated in the course will be made available when signing up for the Resident Engineer Mentorship Programme.

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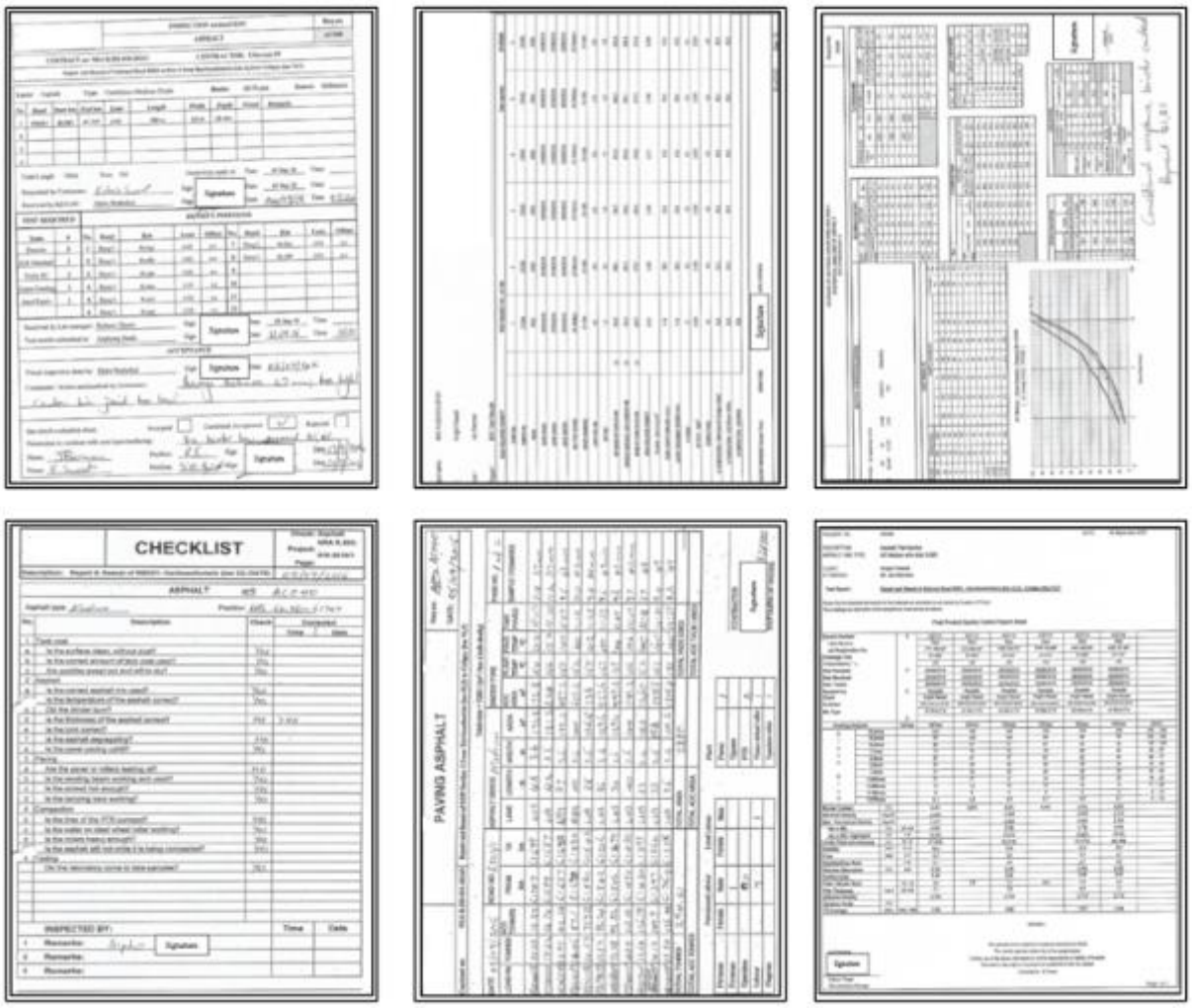
Example of package to be signed off:



19.9. Payment

Payment of asphalt is either done per square meter or in tons. The Bill of Quantities (BoQ) indicates how the asphalt is paid. On the new base or the reconstructed base, the asphalt could either be paid in square meters or in tons. There is a thickness tolerance.

Asphalt is paid in tons if the riding quality must be improved, e.g., overlay over an existing surface.

Important: When asphalt is paid in tons, the asphalt wastage for each day must be calculated and subtracted from payment.

Tack coat is normally applied 0,55ℓ/m^2.

Reduced payment must be applied where applicable with consent from the Engineer.

See ***paragraph 19.6.2*** for calculation of waste asphalt.

FIGURE 78: QUANTITY MEASUREMENT

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20. ROAD MARKING

20.1. Materials

20.1.1. ROAD PAINT

There are three types of paint used for road marking:

1. Thermo plastic – durable and expensive
2. Soluble – less durable, less expensive
3. Water based – not durable and cheap.

Temporary road marking is usually sprayed with soluble paint. Final road marking is sprayed with thermo plastic paint.

20.1.2. ROAD STUDS

The type of road stud is specified in the Bill of Quantities. Alternative road studs must be submitted to the engineer for approval. The road stud must be durable, reflective, and adhere to the specifications.

Permanent road studs are normally specified with a shank. Temporary road studs must not have a shank.

20.2. Pre-Supply Meeting

It is important to have a pre-supply meeting and discuss the following:

1. Traffic accommodation
2. Flagman
3. Type of paint used, no thinners
4. Pre-marking, length of rope, 200m or 400m
5. Hold point, inspection of pre-marking and the start and end of solid lines
6. Thickness of broken, and unbroken and yellow lines
7. Paint application rate, counting of drums
8. Glass plate samples to measure thickness
9. Amount and width of beads
10. Rectify mistakes, sand blast, not black paint
11. Type of road studs to be approved.

Warning: No black paint is allowed to cover mistakes. The incorrect road marking should be sand blasted and covered with emulsion.

These aspects are to be stated in the method statement.

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20.3. Pre-Marking

A long rope must be used for pre-marking to ensure smooth curves are painted on road bends. The Resident Engineer should check for any 'kinks' in the road. The start and finish of solid lines are to be marked on the road and checked by the RE.

Warning: No road marking can be done before the pre-marking is approved by the RE!

20.4. Trial Section

A trial section should be done to check that there are not straight sections in the smooth curves on the road. This should not be done on the completed seal/asphalt. The feathering of the road marking should also be checked, as well as the bead application. Adjustments are to be made where applicable.

20.4.1. TEST

The thickness of the paint must be measured during the trial section by spraying paint on a glass plate.

20.4.2. CHECKLIST

The important aspects to check for road marking are:

1. Are the barrier lines' start and end positions correct?
2. Is the width of the broken lines correct?
3. Is the width of the barrier lines correct?
4. Is the width of the yellow lines correct?
5. Is the spacing between broken lines correct?
6. Is the correct amount of beads used?

Refer to ***Appendix J16*** for a complete checklist.

Important: Make double sure that the line spacing and widths are correct, and that the latest drawings are used. Confirm the width with the Engineer and/or Client. One phone call can prevent great shame.

20.5. Supervision

The spacing and line widths are specified in the standard drawings.

Critical: Drive on the road and check if the start and end marks of barrier lines make sense before they are painted!

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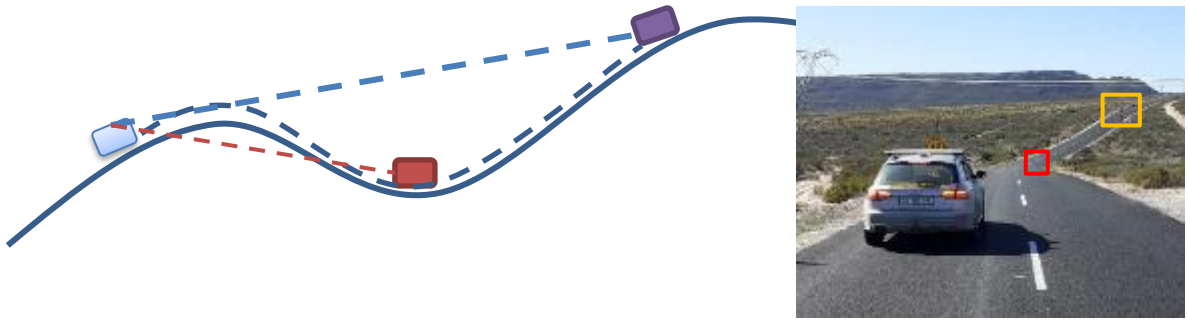

FIGURE 79: POSSIBLE OBSTRUCTIONS WHERE SIGHT DISTANCE IS LIMITED OR UNSAFE

Inform the Engineer about any obstructions around corners where sight distance is limited or unsafe. Change the start and end positions of the barrier lines to make sure that they make sense.

Tip: Set the standard of the pre-marking right in the beginning, improve the smoothness of the first curve while it is set out with the long rope.

20.6. Payment

Example of calculation of broken lines:

Length of broken line: 4m with 8m spacing to the next broken line.

Total length of broken lines: 12 430m.

Payment of broken lines is: 12 460 / 12m x 4m = 1 260m or 1.26km.

Example of payment of road markings:

Payment Item		Description	Unit	Rate	Quantity	Amount	
57.06		Setting out and pre-marking of the lines (excluding traffic-islands, lettering, and symbols)	Km	R 1 000.00	60	R 60 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	5	Km 76.0 – km 80.0 Yellow lines x2 + white centre 4km x 3		12	12	MK	JB

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21. COMPLETION OF PROJECT

21.1. Practical Completion

A practical completion certificate is issued when the work is completed.

Practical completion requirements:

- The traffic flow must be unhindered
- The list of outstanding work must be less than 2% of the contract value
- Outstanding work must be completed within one month
- The liability period starts after practical completion was granted
- No penalty is applied after practical completion has been granted.

Refer to the project document for details.

21.1.1. SNAG LIST

A snag list of the outstanding work is to be given to the contractor after the road is opened for traffic, near the completion of the project.

Tip: Set the standard for cleaning and finishing off slopes for one kilometre.
Give a snag list for each two kilometres.

21.2. As Builts

The following as built forms need to be completed:

Design forms:

- D1 Pavement design
- Drawing typical cross section
- D2 Concrete mix design
- D3 Asphalt mix design
- D4 Seal design
- D5 Stabilisation design

As built layout and test results summaries:

- AB1 Layer works completion schedule
- AB2 Road foundation profile and fill layers
- AB3 Road foundation profile cross section
- AB4 Pavement layers soils and gravels
- AB5 Asphalt test results
- AB6 Pavement layers concrete
- AB7 Seal work completion schedule
- AB8 Crushed stone
- AB9 Rubber bitumen results

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Tip: It is good practice to enter test results in a database format. This makes it easier to use and complete the as built forms.

Any changes on the drawings must be marked and sent to the design office. These revised drawings form part of the as builts to be submitted to the Client.

21.3. Close Out Report

The Close Out report is usually completed by the Resident Engineer at the end of the project.

Tip: It is better to start completing the close out report after 50% to 90% of the project is complete, while the information is still available. Within the last two months of the project, the people with all the information needed from the Contractor are no longer on site. It will take much longer to complete when everyone is no longer on site.

Refer to the following resources for changes made during project to be included both in the close out report and on the drawings:

1. Site instructions
2. Minutes of site meetings
3. Minutes of the technical meetings
4. Emails sent to the Contractor and Client.

Typical content of the close out report includes:

1. Locality plan
2. Contract information
3. Project description
4. Financial details
5. Technical information
6. Procurement
7. Emerging contractor development
8. Contractor's performance
9. Record drawings
10. Permanent expropriation
11. Temporary expropriation
12. Occupational health and safety
13. Environmental aspects
14. Appendices.

21.4. Debriefing

A debriefing presentation is a good way of ending a project. The Resident Engineer would give a presentation of the project to the design office, detailing the project (location, role players, value, period), describing the challenges, achievements, and lessons learned. This is valuable information for persons going to site and the people in the office dealing with the design and documentation of the project. It is an excellent opportunity to transfer valuable skills to the next generation. It is a time to celebrate, refresh, and take on the next project with new vigour and more experience.

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22. SITE SUPERVISION

The Resident Engineer is ultimately responsible for supervision and quality of works on site.

It is important that the Resident Engineer and the site supervision staff familiarise themselves with the scope of work and specifications detailed in the project document and drawings. Set up a meeting with the Engineer and the designer in order to understand what they had in mind and why. All members should know the typical cross section with details of pavement layers, and the traffic accommodation plan by heart.

22.1. Time Management

Time management is crucial for the Resident Engineer. Stories from foremen can waste a lot your time.

Guideline for effective supervision of a project:

1. Check construction activities in the morning about an hour or two after work has started. This is when your input is needed most. Ensure that work has started off correctly. Ask the foreman what the plan is, if the plant is working properly, and if material is approved and not damaged.
2. Check certain construction activities later in the afternoon again, e.g., final cut of base layer, to ensure that no laminations are constructed, or that concrete doesn't become unworkable.
3. Do emails and admin in the afternoon. If the day gets too busy, it is better to do minutes of meetings and other admin at night.
4. **NB!** Teamwork! It is important to set off on the right foot at the start of the day, correct the location and method followed, rather than correcting, or redoing what started off incorrectly in the morning.
5. The beginning of the project requires more time, which means doing admin at night. The project becomes more relaxed towards the second half, as all activities have started, and quality standards have been set.

Important: The Resident Engineer should be present and oversee the start of every task, to ensure that the correct protocols are followed, to establish a line of communication, and to set the standard of work to be completed. After three or four inspections, the task could be delegated to a staff member.

Advice: Ask the foreman, operator, site agent, or laboratory manager for their input into any problem, in order to obtain all possible solutions, and follow the guidelines set out in ***paragraph 24.2***.

Tips: The Resident Engineer should test the technical ability of the new team on site by asking a few questions regarding the task to be completed. Unexpected spot checks should be done to see who could be trusted or relied on in the new team.

Danger: The Resident Engineer should focus and concentrate on the tasks that cost the most money, e.g., asphalt, seal, stabilisation, and structural concrete. If supervision staff is limited, focus supervision on critical tasks and those that are costly. Do not spend most of your time on small activities, like non-structural concrete inlet and outlet structures.

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Important: Be strict at the beginning of a project, and more lenient towards the end. Set a high standard at the beginning, e.g., reject the first layer that doesn't look good.

22.2. Rejecting Work

Guideline for the rejection of work:

1. Investigate the work that does not meet the specification.
2. Why was the specification written? Does that apply to this situation?
3. Confirm with the laboratory if the results had a typing error.
4. Look at the sample in the laboratory for obvious mistakes.
5. Investigate how the sample was taken and transported. Material from the windrow is often sampled instead of material in the road layer.
6. Ask the foreman and supervising staff what happened differently that day, e.g., plant breakdown, etc.
7. Warn the contractor immediately about the failure, verbally or via email.
8. If possible, do extra tests, or retest to confirm the failure.
9. Reject the work officially in the inspection request and registers if you are certain that the work failed, and the laboratory test was done correctly. Confirm the extent of the rejected work in an email.

Note: Refer to ***paragraph 24.7*** for conflict management.

Key Point: Be present during construction, and point out mistakes. It is easy to fix problems while the machines are still there. Rejecting work long after it is done can lead to many frustrations.

22.3. Supervision Staff

The Resident Engineer must delegate his authority to the staff members under him or her. Each member must be given the responsibility to look after a certain section of the work, e.g., stabilisation, culverts, etc.

Tip: It is good practice to distribute tasks to each staff member by focusing on his/her strong points, e.g., admin, visual inspection, and area of expertise.

Delegating the writing of minutes, or updating the daily diary, or updating as builts can be very frustrating for a person who is not administrative. Focus on each person's natural ability.

Task responsibility could be changed halfway through the project to give other members exposure to new tasks they have not done before. Do not do this in the beginning of the project, when the standard of the task is being established on site. There is little risk, after the norm has been set, to change the supervision staff, since by that time, the construction teams know what is expected from them.

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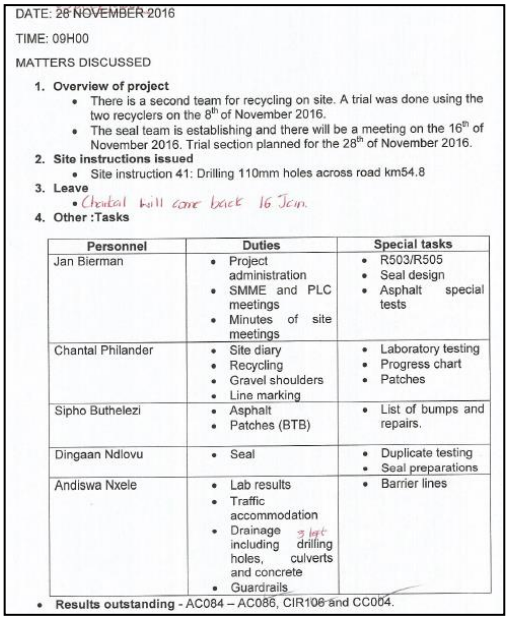
22.4. Weekly Meetings

The Resident Engineer should meet formally with the supervision staff and laboratory manager to plan the week ahead and ensure that each person is given a section/team to supervise.

The following should be discussed at staff meetings:

1. Supervision tasks assigned to each member
2. Special tasks assigned to staff members
3. Site instructions issued and verbal instructions/agreements shared
4. Work weekends, pay weekends, holidays, leave to be co-ordinated each week
5. Progress sheets to be updated
6. Registers to be signed off.

See example in ***Appendix R***.



DATE: 28 NOVEMBER 2016

TIME: 09H00

MATTERS DISCUSSED

1. **Overview of project**
   - There is a second team for recycling on site. A trial was done using the two recyclers on the 8th of November 2016.
   - The seal team is establishing and there will be a meeting on the 16th of November 2016. Trial section planned for the 28th of November 2016.
2. **Site instructions issued**
   - Site instruction 41: Drilling 110mm holes across road km54.8
3. **Leave**
   - Chantal will come back 16 Jan.
4. **Other :Tasks**

Personnel	Duties	Special tasks
Jan Bierman	• Project administration • SMME and PLC meetings • Minutes of site meetings	• R503/R505 • Seal design • Asphalt special tests
Chantal Philander	• Site diary • Recycling • Gravel shoulders • Line marking	• Laboratory testing • Progress chart • Patches
Sipho Buthelezi	• Asphalt • Patches (BTB)	• List of bumps and repairs.
Dingaan Ndlovu	• Seal	• Duplicate testing • Seal preparations
Andiswa Nxele	• Lab results • Traffic accommodation • Drainage including drilling holes, culverts and concrete • Guardrails	• Barrier lines

- **Results outstanding** - AC084 – AC086, CIR106 and CC004.

FIGURE 80: MINUTES OF STAFF MEETINGS

Important: Staff members are to take responsibility for supervising their construction team; visual inspections; the completion of checklists, worksheets, and evaluations; and for signing off test requests. Additionally, supervision staff are to record any delays, like plant breakdowns, weather conditions, late delivery of material, operators not being back after the weekend, etc, in their personal diary.

Note: Staff members are to write a report on any work that failed, explaining possible causes.

22.5. Weekly Monitoring

Advice: It is good practice on large road projects to drive through the site once a week with the site agent, especially at the beginning of the project, to clarify issues and nullify misunderstandings. Make it a standard arrangement, e.g., Tuesdays at 10h00.

Completed worksheets and check lists are to be checked by the Resident Engineer on a weekly basis. Examples shown in signed package, ***paragraph 12.7.4***, ***paragraph 13.6.5***, ***and paragraph 14.7***.

Visual, material, and level sections on test request are to be signed off by. staff members. The Resident Engineer is to sign off on the final acceptance of test requests and the inspection register.

A list of outstanding laboratory results is to be discussed with the laboratory manager at a weekly meeting. Any discrepancies in test results are to be discussed. Correct sampling of material is very important.

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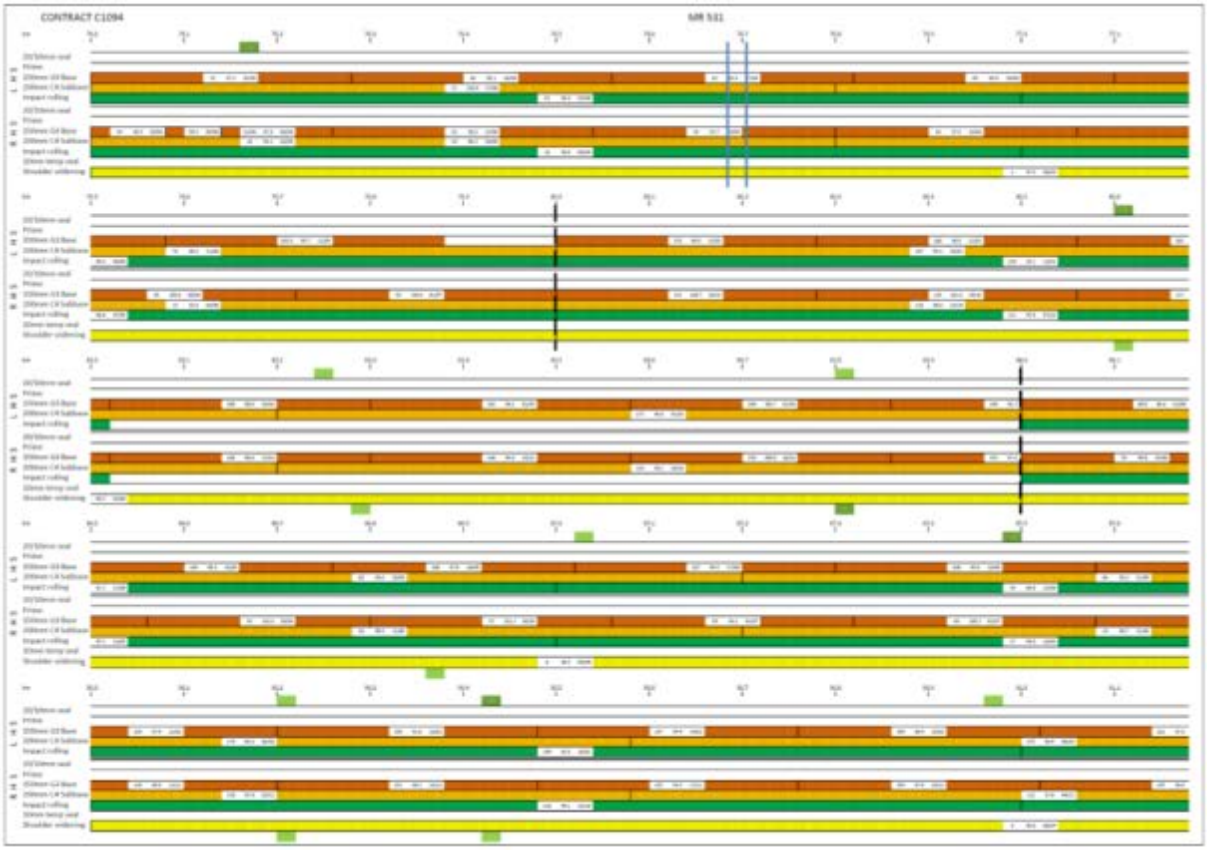
A layout of the layer works, and surfacing should be updated weekly to ensure that there are no gaps or overlaps of the stake values. A table with a list of culverts and concrete elements is to be set up and updated to ensure all aspects were tested, e.g., bedding, alignment, backfill, apron, head, and wingwalls. A layout or table for bridges is to be set up and updated weekly to ensure that all aspects are tested and approved.

Example of layer layout monitoring:



Example of list of culverts and tests completed: Update Test Request PW and date complete:

	MR531 PIPE INSTALLATION LHS					
Stake value	**Size & Class**	**Bedding**	**Base & reinforcement**	**Post-concrete**	**Pipe alignment**	**Back fill**
76+709	2 x 750mm DIA 100D	PW012 - 07/07/2020			PW013 - 07/07/2020	PW014 - 08/07/2020
77+420	2 X 600mm DIA 100D	PW07- 01/07/2020			PW08- 01/07/2020	PW011 - 04/07/2020
85+150	2x900 x 450-175S	PW01- 24/06/2020	SC008 - 15/08/2020	SC009 - 16/07/2020	PW019- 23/07/2019	PW020 - 23/07/2020
88+122	900 x 450-175S	PW01- 24/06/2020	SC005 - 05/08/2020	SC006 - 07/07/2020	PW016- 15/07/2020	PW015 - 15/07/2020

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Example of monitoring elements of bridge structure:

CONCRETE RESULTS - NORTH OVERPASS						
Lab no.	Date cast	Structure		7 Days (Mpa)	28 Days (Mpa)	Required (Mpa)
		Support #	Element			
C368	05/11/2011	Support 1 / West Abutment	Blinding	12.6	18.1	15.0
C387	07/11/2011	Support 2	Blinding	9.3	15.0	15.0
C399	10/11/2011	Support 1 / West Abutment	Base	18.4	30.2	30.0
C450	16/11/2011	Support 2	Base North	24.2	31.3	30.0
C464	17/11/2011	Support 2	Base South	22.9	29.6	30.0
C475	18/11/2011	Support 1 / West Abutment	Column 1 (South)	23.9	29.0	30.0
C476	18/11/2011	Support 3	Blinding	9.4	29.0	15.0
C504	22/11/2011	Support 1 / West Abutment	Column 2 (Centre)	20.7	28.6	30.0
C518	23/11/2011	Support 3	Base North	22.2	33.4	30.0
C520	23/11/2011	Support 3	Base South	21.7	36.5	30.0
C540	29/11/2011	Support 3	Plinths (N and S)	18.7	31.8	30.0
C565	02/12/2011	Support 1 / West Abutment	Column 3 (North)	16.4	28.5	30.0
C592	13/12/2011	Support 1 / West Abutment	Columns 1, 2 and 3 - 2nd Lift	-	30.8	30.0

22.6. Meetings

It is good practice to keep record of all meetings held on site, e.g., subcontractors, SMME's, farm owners, CLO, TSO, etc. This could be done via email or a file note.

The following information is required to give it legal status:

1. Date and time
2. Location
3. Attendance (signed attendance register preferred)
4. Signature (preferred)

The minutes of the meeting should be distributed within a week.

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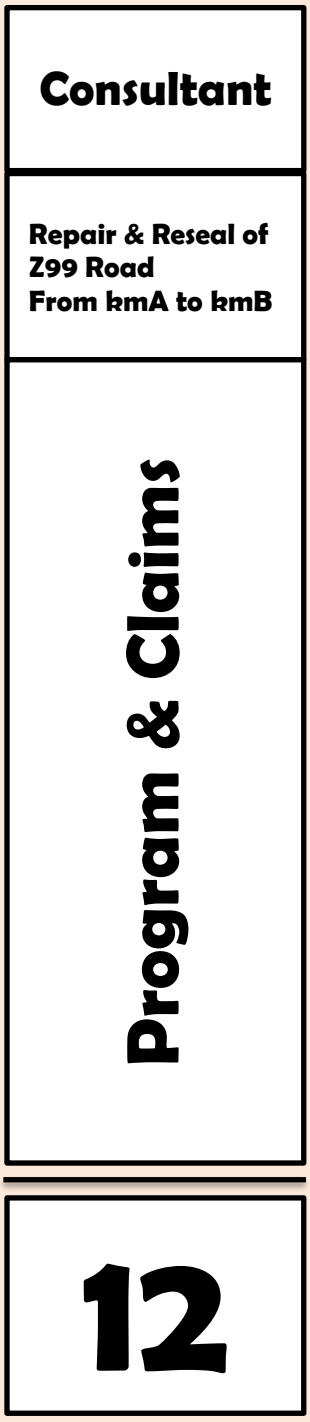
22.7. Filing

Guideline for Filing System on Site and On Computer for Road Projects:

- Contract Documents
- Correspondence
- Site Instructions & Memos
- Minutes of Meetings
- Drawing Register and Transmittals
- Site Investigations and Survey
- Borrow Pits and Materials
- Services - Telkom, Other and Municipal
- Design
- Finance
  - Payment Certificates
  - Daywork,
  - Variation Orders, Extra Work
  - Estimates
- Payment Items
- Payment Backups
- Program, Claims
- General
- Accommodation of Traffic
- Reports
  - Health and safety audit
  - Environmental audit
- Photos
- Admin
  - Templates
  - Travel logsheets
- Technical Manuals
- Roadbed
- Fill
- Selected Layers
- Subbase
- Base
- Seals
- Asphalt
- Culverts
- Drains
- Bridges



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23. FINANCE

23.1. Payment Certificates

The payment certificate is prepared by the Contractor. Work done for the month, normally from the 26th of the previous month till the 25th of the current month.

Important: Quantities are measured according to the dimensions on the drawings, e.g., typical cross sections and concrete dimensions, and not according to the actual quantities done on site!

Note: Excavation is paid according to the dimensions on the drawings plus working space of 0.5m.

Tasks not defined on the drawings are measured on site.

Tip: It is best to measure the quantities with the Contractors (usually the quantity surveyor) instead of each person measuring quantities separately.

Danger: Check COLTO to confirm what is included in the payment item rate. B item – e.g., B14.03 – means the payment items have been changed in the project document.

23.1.1. BACKUPS

Example of backup sheet for payment items:

Consultant Name				QUANTITY MEASUREMENT			
CONTRACT NO. C1094				CONTRACTOR : BASELINE CIVIL CONTRACTORS			
The rehabilitation of main road 531 (km 76.0 to km 92.6, Elandsbay) and the periodic maintenance of main road 540 (km 0.0 to km 12.4, Leipoldtville)							
ITEM DESCRIPTION: PAVEMENT LAYERS OF GRAVEL MATERIAL In situ reconstruction of existing pavement layers as: (c) Gravel selected layer compacted to 95% of maximum dry density, using: (i) Non-cemented material (150mm thick - farm accesses)						SCHEDULE B items No.: B34.04 PAGE ..... OF	
UNIT: m²		BILLED QUANTITY: 850				RATE : 149.22	
ESTIMATE QUANTITY						AMOUNT: 126 837	
DATE	CERT	DESCRIPTION/DIMENSIONS	REF	MEASURED QUANTITY	CUMULATIVE TOTAL	SIGN CONT	SIGN RE

Important: A backup system for the calculation of quantities is essential for audit purposes and to ensure quantities are not measured twice or left out.

Backup for each payment item is required. These sheets need to be signed off by both the Resident Engineer and the Contractor. An Excel spreadsheet with lookup functions is used instead of retyping and printing a page for each item.

See ***Appendix S*** for an example of backup sheet for each payment item.

Most quantities are best calculated on an Excel spreadsheet, e.g., subsoils, or stabilisation. These spreadsheets are printed out and given a reference number. Each payment item then refers to the reference number. Example of reference number: certificate 12, backup sheet no. 3; ref 12.3

The backup description for each reference must very clear and specific stating the time or location to ensure that there is no overlap or double payments.

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Typical descriptions for payment items are:

1. Date
2. Request number
3. Calculations
4. Invoice number
5. Location.

Examples of backup sheet for payment item 42.02. Date or Test request no:

Payment Item		Description	Unit	Rate	Quantity	Amount	
42.01		Asphalt surfacing Continuously medium graded asphalt 45mm thickness	tons	R 2 000	500	R 1 000 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
03/11/08	12	9 – 20 October 2008	12.11	1 307,4	1 307,4	MK	JB
Or							
03/11/08	12	Test request no. AS001 – AS015	12.11	1 307,4	1 307,4	MK	JB

Example of asphalt Reference 12.11:

Lot	Date	Request	Tons	Factor	BC	Voids	Grading	Soft.pt	Density	Remarks
1	09-Oct-08	AS001	136.0	1.00	Pass	Pass	Pass	Pass	Pass	Accepted
2	11-Oct-08	AS002	244.2	1.00	Pass	Pass	Pass	Pass	Pass	Accepted
3	12-Oct-08	AS004	155.7	1.00	Pass	Pass	Pass	Pass	Pass	Accepted
4	14-Oct-08	AS006	263.1	1.00	Pass	Pass	Pass	Pass	Pass	Accepted
5	19-Oct-13	AS012	434.2	1.00	Pass	Pass	Pass	Pass	Pass	Accepted
6	20-Oct-13	AS015	74.3	0.50	Pass	Pass	Pass	Fail	Pass	75tons rejected
	Total		1307.4							

Examples of backup sheet for payment item 22.07 b ii. Location and dimensions:

Payment Item		Description	Unit	Rate	Quantity	Amount	
22.07 b ii		Cast in situ concrete Floor slabs Class 30/19	m^3	R 2 500	10	R 25 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	8	Culvert SV 1,025 LHS					
		Base 2,5m x 6,1m x 0,2m		3,05	3,05	MK	JB

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Example of backup sheet for payment item D10.03 Invoice

Payment Item		Description	Unit	Rate	Quantity	Amount	
D10.03 b		Training Formal training courses: local labour	PC Sum	R 250 000	1	R 250 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/10/20	5	STSA training for concrete works		15 000	15 000	NK	JB

The following items are paid in segments:

Payment item	Paid
12.01 The contractor's fixed obligations	Start 50%, half of work completed, 35%, completed 15%
13.01 to 13.06 and 13.09 Office and laboratory: Accommodation, furniture and fittings	Start 80%, half of work completed, 10%, completed 10%
14.01 Accommodation of traffic and maintaining temporary deviations	Deviation in operation 50%, deviation removed 50%
14.03 Temporary traffic control facilities	Provide and erect 75%, removed 25%
61.03 Access and drainage a) Access	Constructed 75%, removed 25%
61.03 Access and drainage b) Drainage where no access has been provided	Pro-rata
62.07 Establishment of sliding formwork operations	Installed 75%, removed 25%

Example of backup sheet for payment in segments:

Payment Item		Description	Unit	Rate	Quantity	Amount	
13.01		Contractor's general obligations	L/Sum	R 3 000 000	1	R 3 000 000	
Date	**Cert**	**Measurement**	**Ref**	**Measured Quantity**	**Cumulative Total**	**Sign QS**	**Sign RE**
25/03/20	2	Establishment Grader: R 2 750 000 13 000ℓ diesel: R 200 000 2 Containers: R 50 000 Total: R 3 000 000		0.5	0.5	NK	JB
25/01/21	13	Contract value exceed 50%		0.35	0.85	NK	JB
25/09/21	20	Practical completion		0.15	1.00	NK	JB

23.1.2. CONTRACT PRICE ADJUSTMENTS

Contract price adjustment (inflation) is applicable on all items except Provisional Sums, and non-escalatable variation orders. The amount in the scheduled work is escalated using published inflation rates as specified in the project document for Labour (Lt), Plant (Pt), Material (Mt), and Fuel (Ft). These indices are compared to the indices during the tender stage also known as the base month; Labour

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(Lo), Plant (Po), Material (Mo), and Fuel (Fo) and adjusted with factors (x, a, b, c, and d) specified in the project document; contract data.

Example of Contract Price Adjustment:

CONTRACT PRICE ADJUSTMENT - CIVIL ENGINEERING MATERIALS - ROADS, RESEAL (EXCL BITUMEN)

Area for Labour: Western Cape Province
Area for Fuel: N/A
Base Month: Jul-18

x = 0.10 | a = 0.20 | b = 0.35 | c = 0.35 | d = 0.10
Base Indices: L_o = 109.3 | P_o = 101.8 | M_o = 122.1 | F_o = 130.9

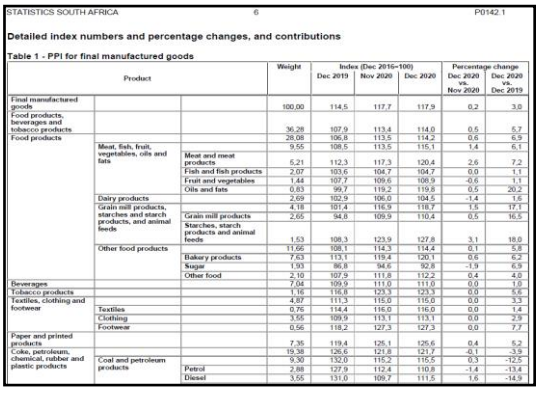
$$f = (1-x)\left(a\frac{L_t}{L_o} + b\frac{P_t}{P_o} + c\frac{M_t}{M_o} + d\frac{F_t}{F_o} - 1\right)$$

Certificate No	Certificate Date	Index Month	Value to be Adjusted from W7	Indices L_t	Indices P_t	Indices M_t	Indices F_t	(P)rov or (F)inal	CPA Adjustment Factor "f"	Adjustment Amount
1	31-Jan-19	Jan-19	276 666.78	110.6	105.9	126.3	117.9	F	0.016725	4 627.25
2	25-Feb-20	Feb-20	2 328 928.28	117.6	109.0	125.6	131.3	F	0.045252	105 388.66
3	16-Mar-20	Mar-20	1 483 921.82	118.3	109.9	125.5	126.4	F	0.045563	67 611.93
4	25-Apr-20	Mar-20	872 054.29	118.3	109.9	125.5	126.4	P	0.045563	39 733.41
5	25-May-20	Mar-20	1 445 588.57	118.3	109.9	125.5	126.4	P	0.045563	65 865.35
TOTAL CONTRACT PRICE ADJUSTMENT ON FORMULA TO W1										283 226.60

23.1.3. RESET OF BASE INDICES

From time to time, the base indices are reset to 100. The calculation of the factor to be used is best explained through an example.

Fuel indices were reset to 100 in December 2019:

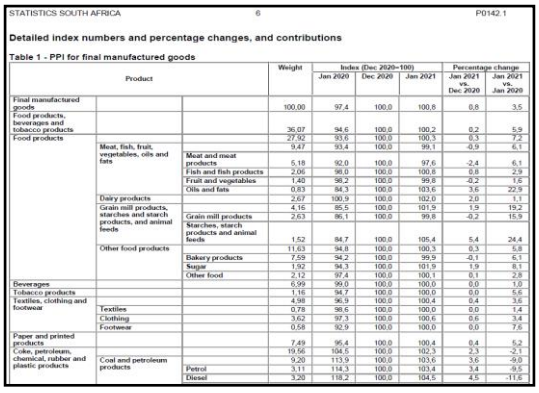


STATISTICS SOUTH AFRICA 6 P0142.1

Detailed index numbers and percentage changes, and contributions

Table 1 - PPI for final manufactured goods

Product			Weight	Index (Dec 2016=100) Dec 2019	Nov 2020	Dec 2020	Percentage change Dec 2020 vs. Nov 2020	Dec 2020 vs. Dec 2019
Final manufactured goods			100,00	114,5	117,7	117,9	0,2	3,0
Food products, beverages and tobacco products			36,28	107,9	113,4	114,0	0,5	5,7
Food products			28,08	106,8	113,5	114,2	0,6	6,9
	Meat, fish, fruit, vegetables, oils and fats		9,55	108,5	113,5	115,1	1,4	6,1
		Meat and meat products	6,21	112,3	117,3	120,4	2,6	7,2
		Fish and fish products	2,07	103,6	104,7	104,7	0,0	1,1
		Fruit and vegetables	1,44	107,7	109,6	108,9	-0,6	1,1
		Oils and fats	0,83	99,7	119,2	119,8	0,5	20,2
	Dairy products		2,69	102,9	106,0	104,5	-1,4	1,6
	Grain mill products, starches and starch products, and animal feeds		4,18	101,4	116,9	118,7	1,5	17,1
		Grain mill products	2,65	94,8	109,9	110,4	0,5	16,5
		Starches, starch products and animal feeds	1,53	108,3	123,9	127,8	3,1	18,0
	Other food products		11,66	108,1	114,3	114,4	0,1	5,8
		Bakery products	7,63	113,1	119,4	120,1	0,6	6,2
		Sugar	1,93	86,8	94,6	92,8	-1,9	6,9
		Other food	2,10	107,9	111,8	112,2	0,4	4,0
Beverages			7,04	109,9	111,0	111,0	0,0	1,0
Tobacco products			1,16	116,8	123,3	123,3	0,0	5,6
Textiles, clothing and footwear			4,87	111,3	116,0	116,0	0,0	3,3
	Textiles		0,76	114,4	116,0	116,0	0,0	1,4
	Clothing		3,55	109,9	113,1	113,1	0,0	2,9
	Footwear		0,56	118,2	127,3	127,3	0,0	7,7
Paper and printed products			7,35	119,4	125,1	125,6	0,4	5,2
Coke, petroleum, chemical, rubber and plastic products			19,38	126,6	121,8	121,7	-0,1	-3,9
	Coal and petroleum products		9,30	132,0	115,2	115,5	0,3	-12,5
		Petrol	2,88	127,9	112,4	110,8	-1,4	-13,4
		Diesel	3,55	131,0	109,7	111,5	1,6	-14,9



STATISTICS SOUTH AFRICA 6 P0142.1

Detailed index numbers and percentage changes, and contributions

Table 1 - PPI for final manufactured goods

Product			Weight	Index (Dec 2020=100) Jan 2020	Dec 2020	Jan 2021	Percentage change Jan 2021 vs. Dec 2020	Jan 2021 vs. Jan 2020
Final manufactured goods			100,00	97,4	100,0	100,8	0,8	3,5
Food products, beverages and tobacco products			36,07	94,6	100,0	100,2	0,2	5,9
Food products			27,92	93,6	100,0	100,3	0,3	7,2
	Meat, fish, fruit, vegetables, oils and fats		9,47	93,4	100,0	99,1	-0,9	6,1
		Meat and meat products	6,18	92,0	100,0	97,6	-2,4	6,1
		Fish and fish products	2,06	96,0	100,0	100,8	0,8	2,9
		Fruit and vegetables	1,40	98,2	100,0	99,8	-0,2	1,5
		Oils and fats	0,83	84,3	100,0	103,6	3,6	22,9
	Dairy products		2,67	100,9	100,0	102,0	2,0	1,1
	Grain mill products, starches and starch products, and animal feeds		4,16	85,5	100,0	101,9	1,9	19,2
		Grain mill products	2,63	86,1	100,0	99,8	-0,2	15,9
		Starches, starch products and animal feeds	1,52	84,7	100,0	105,4	5,4	24,4
	Other food products		11,63	94,8	100,0	100,3	0,3	5,8
		Bakery products	7,59	94,2	100,0	99,9	-0,1	6,1
		Sugar	1,92	94,3	100,0	101,9	1,9	8,1
		Other food	2,12	97,4	100,0	100,1	0,1	2,8
Beverages			6,99	99,0	100,0	100,0	0,0	1,0
Tobacco products			1,16	94,7	100,0	100,0	0,0	5,6
Textiles, clothing and footwear			4,98	96,9	100,0	100,4	0,4	3,6
	Textiles		0,78	98,6	100,0	100,0	0,0	1,4
	Clothing		3,62	97,3	100,0	100,6	0,6	3,4
	Footwear		0,58	92,9	100,0	100,0	0,0	7,6
Paper and printed products			7,49	95,4	100,0	100,4	0,4	5,2
Coke, petroleum, chemical, rubber and plastic products			19,56	104,5	100,0	102,3	2,3	-2,1
	Coal and petroleum products		9,20	113,9	100,0	103,6	3,6	-9,0
		Petrol	3,11	114,3	100,0	103,4	3,4	-9,5
		Diesel	3,20	118,2	100,0	104,5	4,5	-11,6

Month	Diesel Indices		CPA
	Old	New	
November 2020	109,7		109,7
December 2020	111,5	100,0	111,5
January 2021		104,5	116,5
February 2021		105,8	117,9

Increase factor from December to January 104,5/100,0 = 1,045 (thus a 4,5% increase)
Increase from January to February 105,8/104,5 = 1,012 (thus a 1,2% increase)

Calculation of adjusted diesel indices for:
January 111,5 x 1,045 = 116,5
February 116,5 x 1,012 = 117,9

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W8.1

CONTRACT NO C1094 PAYMENT CERTIFICATE NO. 15

THE REHABILITATION OF MAIN ROAD 531 (KM 76.0 TO KM 92.6, ELANDS BAY) AND THE PERIODIC MAINTENANCE OF MAIN ROAD 540 (KM 0.0 TO KM 12.4, LEIPOLDTVILLE)

CONTRACT PRICE ADJUSTMENT - CIVIL ENGINEERING MATERIALS - ROADS, RESEAL (EXCL BITUMEN)

Area for Labour: Western Cape Province
Area for Fuel: N/A
Base Month: Jul-18

x = 0.10 | a = 0.20 | b = 0.35 | c = 0.35 | d = 0.10
Base Indices: L_o = 109.3 | P_o = 101.8 | M_o = 122.1 | F_o = 130.9

$$f = (1-x)\left(a\frac{L}{L_o} + b\frac{P_1}{P_o} + c\frac{M_1}{M_o} + d\frac{F_1}{F_o} - 1\right)$$

Certificate No	Certificate Date	Index Month	Value to be Adjusted from W7	Indices L_1	Indices P_1	Indices M_1	Indices F_1	(P)rov or (F)inal	CPA Adjustment Factor 'F'	Adjustment Amount
1	31-Jan-19	Jan-19	276 666.78	110.6	106.9	126.3	117.9	F	0.016725	4 627.25
2	25-Feb-20	Feb-20	2 328 928.28	117.6	109.0	125.6	131.3	F	0.048252	105 388.66
3	16-Mar-20	Mar-20	1 483 921.82	118.3	109.9	125.5	126.4	F	0.045563	67 611.93
4	25-Apr-20	Apr-20	872 054.29	117.6	111.0	124.1	113.8	F	0.035539	30 991.94
5	25-May-20	May-20	1 445 588.57	116.8	112.7	121.6	99.3	F	0.023063	33 339.61
6	25-Jun-20	Jun-20	2 824 799.31	117.5	112.8	122.0	101.2	F	0.026863	75 882.58
7	25-Jul-20	Jul-20	3 971 945.49	118.8	112.8	121.9	116.9	F	0.039541	157 054.70
8	25-Aug-20	Aug-20	5 362 991.71	119.1	115.2	123.9	121.0	F	0.055440	297 324.26
9	25-Sep-20	Sep-20	2 942 017.05	119.4	115.1	124.4	119.1	F	0.055608	163 599.68
10	25-Oct-20	Oct-20	3 814 656.24	119.7	116.2	125.2	110.7	F	0.055794	212 834.93
11	25-Nov-20	Nov-20	5 519 449.73	119.7	116.0	124.3	109.7	F	0.052166	287 927.61
12	25-Dec-20	Dec-20	1 795 206.87	120.0	115.9	128.2	111.5	F	0.063650	114 264.92
13	25-Jan-21	Jan-21	3 308 562.21	120.4	116.6	127.0	116.5	F	0.066816	221 066.23
14	25-Feb-21	Jan-21	6 980 914.42	120.8	117.0	127.2	117.9	F	0.070191	489 997.36
15	15-Mar-21	Jan-21	4 559 591.51	120.8	117.0	127.2	117.9	P	0.070191	320 042.29

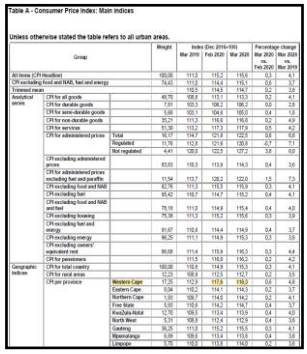
Table A - Consumer Price Index: Main indices

Unless otherwise stated the table refers to all urban areas.

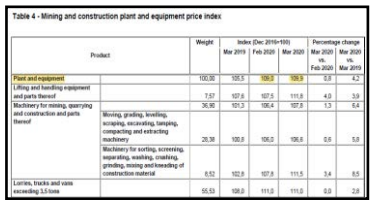
Table 4 - Mining and construction plant and equipment price index

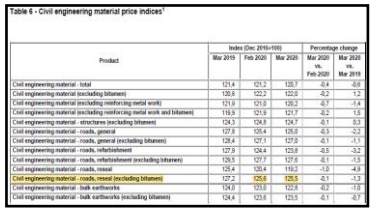
Table 6 - Civil engineering material price indices[1]

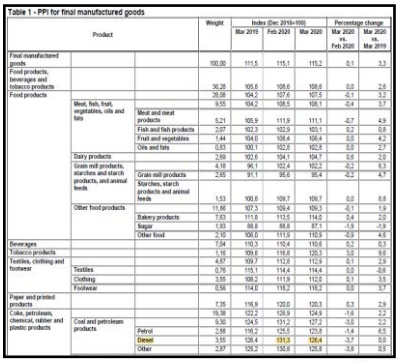
Table 1 - PPI for final manufactured goods

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23.1.4. SPECIAL MATERIALS

Special materials or bitumen products are escalated separately. This escalation (inflation) is related to the bitumen price. The difference of the current bitumen price and the bitumen price at tender stage, known as the base month, is multiplied by the quantity of the bitumen used for the month.

Example of escalation of special materials:

SUMMARY OF RISE AND FALL

DATE	CERT	DESCRIPTION	UNIT		QUANTITY	BITUMEN % ACTUAL	BITUMEN QUANTITY	BITUMEN BASE RATE	BITUMEN CURRENT RATE	RATE VARIANCE	TOTAL ORIGINAL VALUE	TOTAL CURRENT VALUE	TOTAL RISE & FALL
		Prime	T		78 171.60		0			R -	R0.00	R0.00	R0.00
Apr-18	14	Prime MC-30	T	1	39 508.00	30.00%	11.85	R 5 916.00	R 6 742.28	R 826.28	R70 116.43	R79 909.50	R9 793.07
May-18	15	Prime MC-30	T	1	12 852.00	30.00%	3.86	R 5 916.00	R 7 134.03	R 1 218.03	R22 812.10	R27 508.82	R4 696.72
Jun-18	16	Prime MC-30	T	1	22 834.40	30.00%	6.85	R 5 916.00	R 7 891.95	R 1 975.95	R40 524.60	R54 059.86	R13 535.26
Oct-18	20	Prime MC-30	T	1	2 977.20	30.00%	0.89	R 5 916.00	R 9 342.36	R 3 426.36	R5 282.99	R8 342.73	R3 059.74
		Double Seal			94 281.00								
May-18	15	Double seal	t	1.029	3 280.00	100.00%	6.75	R 4 300.00	R 5 650.00	R 1 350.00	R29 026.03	R38 138.86	R9 112.82
Jun-18	16	Double seal	t	1.029	86 941.00	100.00%	178.92	R 4 300.00	R 6 250.00	R 1 950.00	R769 375.69	R1 118 278.61	R348 902.93
Oct-18	20	Double seal	t	1.029	4 060.00	100.00%	8.36	R 4 300.00	R 7 050.00	R 2 750.00	R35 928.56	R58 906.13	R22 977.57
		Bituminous binder variation			49 222.50								
Jun-18	16	binder variation	t	1.029	5 644.95	100.00%	5.81	R 4 300.00	R 6 250.00	R 1 950.00	R24 977.23	R36 304.11	R11 326.88
Oct-18	20	binder variation	t	1.029	43 577.54	100.00%	44.84	R 4 300.00	R 7 050.00	R 2 750.00	R192 817.55	R316 131.09	R123 313.55
		Precoating 19mm stone			1 520.66								
May-18	15	Precoating 19mm stone	t	1.029	43.73	60.00%	0.43	R 4 300.00	R 5 650.00	R 1 350.00	R1 867.67	R2 440.89	R583.22
Jun-18	16	Precoating 19mm stone	t	1.029	1 435.57	60.00%	14.18	R 4 300.00	R 6 250.00	R 1 950.00	R60 978.88	R88 632.09	R27 653.21
Oct-18	20	Precoating 19mm stone	t	1.029	41.36	60.00%	0.41	R 4 300.00	R 7 050.00	R 2 750.00	R1 756.85	R2 880.42	R1 123.57
		Precoating 9.5mm Stone			663.95								
May-18	15	Precoating 9.5mm Stone	t	1.029	19.88	60.00%	0.23	R 4 300.00	R 5 650.00	R 1 350.00	R1 002.72	R1 317.52	R314.81
Jun-18	16	Precoating 9.5mm Stone	t	1.029	626.01	60.00%	7.34	R 4 300.00	R 6 250.00	R 1 950.00	R31 576.93	R45 896.71	R14 319.77
Oct-18	20	Precoating 9.5mm Stone	t	1.029	18.06	60.00%	0.21	R 4 300.00	R 7 050.00	R 2 750.00	R910.97	R1 493.58	R582.60
		Fog Spray			73 199.60								
Jun-18	16	CAT 30	l	1.000	69 853.20	30.00%	20.96	R 4 365.93	R 6 194.44	R 1 828.51	R91 492.25	R129 810.44	R38 318.18
Oct-18	20	CAT 30	l	1.000	3 346.40	30.00%	1.00	R 4 365.93	R 7 483.47	R 3 117.54	R4 383.04	R7 512.81	R3 129.76
		TOTAL VALUE OF SPECIAL MATERIALS TO PAGE 9									R1 384 820.50		
		TOTAL VALUE OF SPECIAL MATERIALS TO PAGE 2											R632 743.67

Base month bitumen rate is specified in the tender document, blue or yellow pages of the project document.

Example:

GAUTENG PROVINCE
Department: Roads and Transport
REPUBLIC OF SOUTH AFRICA

TENDER No. DRT 24/10/2015
FOR CONSTRUCTION OF ROADWORKS AND UPGRADING FOR GRAVEL ROAD D 1944 (11.35km)

T2.3 C RATES FOR SPECIAL MATERIALS

Only bitumen products will be dealt with as a special material in terms of sub-clause 6.8.3 of the General Conditions of Contract. All bitumen products as indicated in the contract data must be stated in the list below.

The rates and prices for the special materials shall be furnished by the contractor, which rates and prices shal exclude VAT but shall include all other obligatory taxes and levies.

SPECIAL MATERIALS	UNIT *	RATE OR PRICE FOR THE BASE MONTH
BITUMEN 70/100	t	R4300 BULK
BITUMEN 60/70	t	R 4400 BULK
MC 30 PRIME	t	R 5916 BULK

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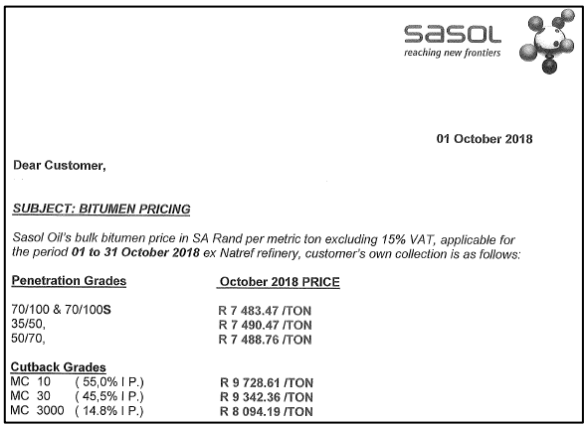
Current price of bitumen from suppliers:



sasol
reaching new frontiers

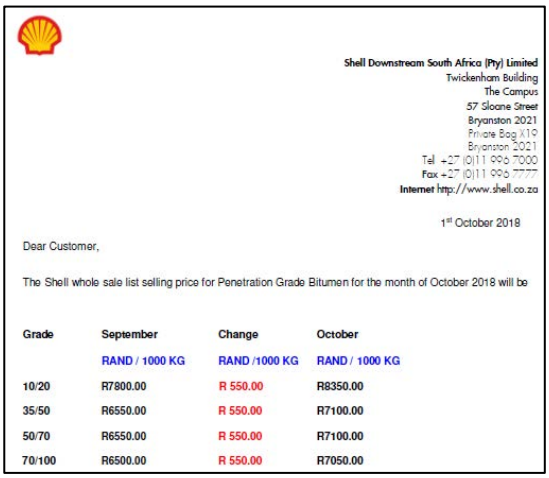
01 October 2018

Dear Customer,

SUBJECT: BITUMEN PRICING

*Sasol Oil's bulk bitumen price in SA Rand per metric ton excluding 15% VAT, applicable for the period **01 to 31 October 2018** ex Natref refinery, customer's own collection is as follows:*

Penetration Grades	October 2018 PRICE
70/100 & 70/100S	R 7 483.47 /TON
35/50,	R 7 490.47 /TON
50/70,	R 7 488.76 /TON
Cutback Grades	
MC 10 (55,0% I P.)	R 9 728.61 /TON
MC 30 (45,5% I P.)	R 9 342.36 /TON
MC 3000 (14.8% I P.)	R 8 094.19 /TON



Shell Downstream South Africa (Pty) Limited
Twickenham Building
The Campus
57 Sloane Street
Bryanston 2021
Private Bag X19
Bryanston 2021
Tel +27 (0)11 996 7000
Fax +27 (0)11 996 7777
Internet http://www.shell.co.za

1st October 2018

Dear Customer,

The Shell whole sale list selling price for Penetration Grade Bitumen for the month of October 2018 will be

Grade	September	Change	October
	RAND / 1000 KG	RAND /1000 KG	RAND / 1000 KG
10/20	R7800.00	R 550.00	R8350.00
35/50	R6550.00	R 550.00	R7100.00
50/70	R6550.00	R 550.00	R7100.00
70/100	R6500.00	R 550.00	R7050.00

23.1.5. RISE AND FALL CALCULATIONS

Special materials, such as bitumen, are escalated separately from the other materials and are called rise and fall.

Examples of rise and fall calculations:

1. Prime: BoQ item 41.01: 2977 litre x 30% bitumen in MC30 / 1000 litre/ton = 0.89 tons
   Amount rise and fall: 0.89 x (R5 916 – R9 342.36) = R3 060

2. Seal work using 70/100 penetration bitumen
   Double seal area, BoQ item 45.01 a): 4 060m^2

   a. Nominal application rate cold net binder: COLTO table 4503/1 & 4503/2: 1,0ℓ/m^2 (19mm) + 1,0ℓ/m^2 9,5mm) = 2,0ℓ/m^2
      Total rise & fall price difference: R7050-R4300
      Amount rise & fall: 4060m^2 x 2,0ℓ/m^2 x 1,029 litre/kg / 1000kg/ton x (R7050-R4300) = R22 977

   b. Variation litres: BoQ item 45.02 a): 47 500 litres hot bitumen / 1.09 = 43 577 litres cold net bitumen

      Amount rise & fall: 43 577 litre x 1,029 litre/kg / 1000kg/ton x (R7050-R4300) = R123 313

3. Pre-coating 19mm stone, BoQ item 41m^3 x 16ℓ/m^3 x 60% bitumen in pre-coating (supplier) = 393ℓ
   Amount rise & fall: 393ℓ x 1,029ℓ/kg / 1000 kg/ton x (R7050-R4300) = R 1 114

4. Fog spray diluted to 30% emulsion
   BoQ item 45.04: 3346 litres x 30% bitumen in emulsion / 1000 litres/ton = 1 004tons
   Amount rise & fall: 1 004 tons x (R7483.47-R4365.93) = R 3 130

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Calculations using other products:

1. Seal work modified bitumen (S-E1 with 3% latex), 3% of litres sprayed to be deducted.

2. Seal work rubber bitumen (20% rubber crumbs to be deducted from the litres sprayed)

3. Asphalt (60/70 pen bitumen)
   BoQ item 42.02: 250 tons x 4,5% bitumen (asphalt design) = 11.25 tons
   Amount rise & fall: 11.25 tons x (R7 100 – R4 400) = R30 375

4. Slurry (design 7,2% bitumen)
   BoQ item 48.03: 180m^3 x 2.35 tons/m^3 (bulk relative density) x 7.2% = 30.46tons
   Amount rise & fall: 30.46tons x (R7 483.47 – R4 365.93) = R94 948

5. Emulsion treated base (patching with 3% emulsion)
   BoQ 39.03: 150m^3
   Bitumen: 180m^3 x 2.25tons/m^3 (wet density) x 3% emulsion x 60% bitumen in emulsion = 7.29tons
   Amount rise & fall: 7.29 x (R7 483.47 – R4 365.93) = R22 727

23.1.6. MATERIALS ON SITE

Only 80% of the value of materials on site are paid in the monthly payment certificate. The Resident Engineer and the Contractor (QS or SA) must measure the material on site on the last day when quantities are measured, usually the 25th of the month. All tanks are to be dipped, e.g., prime, emulsion, pre-coating, etc. The pipes, ducts, and cement in the yard must be counted. The stockpile of material delivered, e.g., seal aggregate, or G3, is to be roughly measured and compared to the delivery notes, minus what was used/paid. Reinforcing steel is difficult to check, use delivery notes and subtract what was used on site, roughly compare quantity with what is seen in the yard.

Warning: Do not pay for material that was brought but not delivered to site. All such arrangements must the approved by the Client, e.g., culverts, crushed stone, seal aggregates, etc.

Example of measuring stockpile
Volume = average width x average length x average hight = 5m x 8m x 1.5m = 60m^3

23.2. Variation Orders

A variation order is issued for the following:

1. Claims for extension of time
2. Extra work or additional work
3. Design or specification change
4. Increase of measurable quantities (e.g., > R15 000) or increase in section cost (e.g., > R300 000)
5. New rates.

The variation order is normally prepared by the Resident Engineer but signed by the Engineer and approved by the Client before it is paid.

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A variation order is only submitted when the final amount of the change or claim is known. This could take many months.

Important: Claims that have a financial impact must be agreed before they will be paid. A change order is used if the amount of the financial impact is not fully known.

The worst thing for a Client is to become aware at the end of the contract that the budget amount will be overspent. This puts pressure on the Client to pay the Contractor and puts the Engineer in a bad light.

Remember: State whether the variation order can be escalated. New rates can be backdated to the base month using the CPA rate (inflation), so that the order can be escalated.

23.2.1. CHANGE ORDER

A change order is a pre-approval of a variation order. It is the approval of the claim/change/event/circumstance before the total amount can be calculated. It is an early warning system that more money is needed for what has happened, or the impact of changes.

Tip: Submit a small report with the change order/variation order to have it approved more quickly.

The best way to have a change order or variation order approved is to write a two-to-three-page motivation, with sketches and price implications, and submit it with the change order/variation order. Write the report in basic terms for accountants to understand. Give a brief background about the scope and purpose of the project, state the problem, and the cost of a possible solution, with a conclusion and recommendation.

23.3. Estimate

It is important to do an estimate at the beginning (within two to three months) of the contract to see how much 'fat' (extra money) has been allowed for changes/contingencies. Without knowing how much money is available for changes, it is very difficult to make decisions on site. Most decisions on site have a financial implication. The Resident Engineer must make decisions based mainly on cost and how it will affect the overall budget.

23.3.1. COST OF ACTIVITIES

It is important for a Resident Engineer to know how much the main activities cost on the project. This empowers the Resident Engineer to make quick decisions. Cost of activities are calculated in meter or square meter.

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Examples of cost of activities from previous contracts:

1. Culverts 600mm diameter (2017)
   Excavation: 1m long x 1.3m wide x 1.5m deep @ R63.53/m^3 = R123.88/m
   Backfill: excavation – pipe area = 1.3 x 1.5 – 22/7 x 0.35^2 @ R150.02/m^3 = R234.78/m
   600mm diameter pipe = R1 095.02
   Total: R123.88 + R234.78 + R1 095.02 = R1 453.68/m

2. Mill and reconstruct (2012)
   Removing existing seal layer 1m x 1m x 0.03m @ R264.71/m^3 = R7.94
   Recycle existing road 1m x 1m x 0,15m @ R21.23 = R3.18/m^2
   Cement: 1m x 1m x 0.15m x 2.1 x 2% @ R1 551.29 = R9.77/m^2
   Curing: 1m x 1m @ R0.46/m^2 = R0.46/m^2
   Total R21.35/m^2

3. Seal (2016)
   Double seal 1m x 1m @ R40.03 = R40.03/m^2
   Binder variation 1m x 1m x (1.5ℓ/m^2 + 1.2ℓ/m^2 – 1ℓ/m^2 x 1.08 hot – 1ℓ/m^2 x 1.08 hot) @ R5.92/litre = R3.20/m^2
   19.0mm aggregate variation: Actual $1m^2/62m^2/m^3$ = 0.01613m^3
   Nominal $1m^2$ / $75m^2/m^3$ = 0.01333m^3
   Variance (0.01613m^3 – 0.01333m^3) @ R609.68/m^3 = R1.71/m^2
   9,5mm aggregate variation: Actual: $1m^2$ / $142m^2/m^3$ = 0.00704m^3
   Nominal $1m^2/165m^2/m^3$ = 0.00606m^3
   Variance (0.00704m^3 – 0.00606m^3) @ R609.68/m^3 = R0.60/m^2
   Fog spray 1m x 1m x 0.8ℓ/m^2 @ R4.49 = R3.59/m^2
   Precoating 19mm $1m^2/62m^2$/3 x @ R192.61 = R3.11/m^2
   Precoating 9.5mm $1m^2/142m^2$/3 @ R192.61 = R1.36/m^2
   Total seal R50.49/m^2

4. Asphalt (2016)
   Asphalt tack 1m x 1m x 0.55ℓ/m^2 @ R4.24 = R 2.33/m^2
   Asphalt 1m x 1m x 0.03m x 2.45tons/m^3 @ R1 065.30 = R78.30/m^2
   Total R80.63/m^2

5. Fog spray
   Fog spray 1m x 1m x 0.8ℓ/m^2 @ R4.49 = R3.59/m^2

6. Slurry (2016)
   Slurry 1m x 1m x 0.006m @ R1 900/m^3 = R11.40/m^2

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7. Patching (2016)
   Saw asphalt 1m x 4 x 0.03m @ R53.00/m^2 = R6.36/m^2
   Excavation 1m x 1m x 0.18m @ R318/m^3 = R57.24m^2
   Backfill ETB 1m x 1m x 0.15m @ R477/m^3 = R71.55m^2
   Compacting the floor 1m x 1m @ R2.77/m^2 = R2.77/m^2
   Asphalt tack coat 1m x 1m x 0.55ℓ/m^2 @ R58.34/ℓ = R32.09/m^2
   Asphalt 1m x 1m x 0.03m x 2.45tons/m^3 @ R1 091.80/ton = R80.25/m^2
   Total R250.26/m^2

Note: Patches are normally three to four times more expensive than rehabilitation.

23.3.2. RATES BREAKDOWN

The payment rate for each activity is made up by the following:

1. Material (including/excluding delivery)
2. Plant (including diesel and operator)
3. Labour (team leader/foreman, skilled labour, unskilled labour)
4. Waste (normally taken as 5%, small quantities such as asphalt patching is much more)
5. Mark up (usually 10% to 15%)
6. It is important to know how much of the rate is made up by each of the above.

Example:

The Contractor submits a new rate for using different blocks for block paving. If the breakdown of the block paving is known, it is easy to check if the new rate is reasonable by substituting only the material price while the labour and waste remains the same.

A breakdown of new rates should always be requested from the Contractor. This could be compared to other similar projects or similar rates in the Bill of Quantities.

23.4. Claims

The Contractor must claim within 28 days after becoming aware of the event against which it will be necessary to claim. If the effect/amount of the claim is not known immediately, or ongoing, the Contractor must give a notice to claim within 28 days after becoming aware of the incident/circumstance. The Engineer has 14 days to respond or give a ruling on the claim. The claims could be time barred if the Contractor does not give notice to claim when he or she became aware of the problem.

The basis for a claim is based on what information was available at tender stage of the contract, and what the Contractor's obligations are. Rates are based on what was known at tender stage. Any changes to that information could lead to a claim or change of rates or new rates. Such claims are legitimate and must not be taken personally.

Refer to the hierarchy of documents when there are discrepancies between the project specifications, the drawings, and the bill of quantities.

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Good record keeping is critical for evaluation of claims. The Resident Engineer must keep a personal diary, a site diary, photos, and a record of the weather (rain, mist, cold temperatures, and sometimes even road temperatures) for the Engineer to properly evaluate a claim.

The sequence of events must be presented when evaluating a claim, for example:

- 15 March – 10mm rain in the morning
- 17 March – Grader breakdown
- 19 March – Meeting with Client
- 21 March – Special test done

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24. PROJECT MANAGEMENT

Project results include both *product* results, the works of the contractor, and *contract administration* results, such as cost (cash flow) and time-schedule performance.

Source: SANRAL Bridges and Structures Manual, par 2.9.4 Quality Control page 2-24.

Project management is not needed when everything goes right on site but is essential when things go wrong.

Project management is about achieving the overall objective through a process of taking the interest of third parties into account and finding a middle ground that is acceptable to all the role players.

Project management is about building teamwork, establishing a good norm on site, limiting risk, being proactive, and handling disputes and failed/rejected works. It is the art of knowing when to be strict and when to be lenient. It is the art of knowing what the right thing to do is, vs what the best thing to do is.

24.1. Timeous Decisions

Experience has proven that it is better for the Resident Engineer to make a decision on site than not making a decision, or making the right decision too late.

The effect of making no decision has a huge impact on the overall contract, and can lead to losing leadership, respect, and control. The Contractor will eventually have to make a decision on a matter that is not resolved, as he will be delayed and/or lose money.

When the Contractor makes a decision, the main consideration is cost. When the Resident Engineer makes a decision, it is necessary to take the interests of all parties into consideration, the Client, the public, the community, and third parties. Although it may not be the best decision, a way forward with integrity, and if necessary, taking a calculated risk, must be determined. It is difficult to make a call on a matter when all the information is not immediately available.

Important: It is best to act now, than not to act, or to act too late on a matter that needs to be resolved.

Project management is taking the best decision now with the available information, after analysing the functionality, risks, cost, and impact of each situation.

Example 24.1: Tie-in levels not correct

New design levels on a rehabilitated section of road are 150mm higher than the tie-in point of the existing road. The Contractor asks the resident Engineer what to do; the machines are standing. A quick decision needs to be made, otherwise the Contractor will either make a decision that suits him/her best or claim for standing time. Contractors do not always take the structural capacity of the pavement into consideration, for example, not constructing a subbase layer over the last 20 metres.

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Decision: Drop design levels over 30 metres to tie-in to the existing road, and keep the structural pavement as per the design, e.g., base and subbase.

24.2. Problem Solving

Details of the standard drawings are not always applicable to the specific site conditions, and changes need to be made to compensate. The same goes for the general specifications in COLTO/COTO; they are not always applicable to the situation or use on site. Therefore, engineering judgement must be applied, and the risk must be analysed, in order to ensure that the change/solution is fit for the purpose of solving the problem.

The following approach should be followed to solve a problem on site:

1. Get all the possible solutions to the problem
    a. Think outside the box, what can be done if you had all the money and resources available?
    b. Start by asking the experienced foreman on site
    c. Ask the Site Agent what he thinks
    d. Ask your own staff or a colleague for solutions
2. Evaluate all the solutions on the follow criteria:
    a. Is it functional, will it work?
    b. What are the risks? Short term and long term.
    c. How much will it cost?
    d. How long will it take?
3. What is the overall effect on the project, public and the client?

After evaluating these, choose the best solutions.

Sample matrix to be followed:

Solutions	Functional	Risk	Cost	Time	Overall effect
Solution 1	Yes	High	R 1.2 million	2 months	Setting a poor standard at start of project
Solution 2	No	Low	R 0.8 million	5 weeks	Aesthetics bad
Solution 3	Yes	Low	R 1.8 million	3 months	Costly, but establish good standard as start of project

Important: It is important to set a high standard of work in the beginning of the project. Have your big fight at the beginning about something that is important. Do not be lenient at that start, as it sets a low standard for the rest of the project.

It is senseless to be unnecessarily strict towards the end of the project, and it won't be required, as the standard for work has been established.

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24.3. Balance Between Strict and Lenient

The Resident Engineer needs to find a balance between being strict and lenient and taking responsibility with the risks that are involved. Not all specifications are cast in stone, concessions could be made if you understand the risk involved and application for the specification. Engineering judgement is required to apply, or not apply, or change standard specification in certain conditions. Work or material that is not within specification but fit for a specific purpose on-site may be accepted. A comprehensive risk analysis is essential, as well as making use of the give and take principle.

Example 24.2: Seal embargo

The seal embargo period is specified in the project document. This is done for planning purposes and to limit the risk of the seal stripping due to the low night temperatures. If the night temperatures are still high in the embargo period, there is little risk of the seal stripping. A cession could be given to seal during the embargo period based on the weather predictions of the night temperatures.

Seal work must stop at 15h00. This specification is to allow enough time to broom and roll the completed seal for the day. This specification is not applicable when only a small section is sealed in the afternoon, or when sealing in summer and the sun sets 20h30 in the Western Cape vs 17h00 in winter.

If a cession is not given, being unnecessarily strict, the Resident Engineer will be disrespected and teamwork will be hampered.

24.3.1. BEING TOO STRICT

Effects of Resident Engineer being too strict:

- Consultant rules by the book
- No engineering judgement for practical implementation
- RE focuses on small unimportant tasks/details, nit-picking
- Contractor gets frustrated and takes short cuts, as he is losing money due to small trivial issues
- Contractor claims for everything that is wrong in the documents
- Relationships are bad and Contractor is not interested in producing excellent work.

Conclusion:

- Quality suffers, everyone in the office is accusing or defending, no one is looking at construction on site.
- When the relationship between Site Agent and Resident Engineer has gone bad, there is no success, therefore it is necessary to replace one or both.

Example 24.3: Density of bottom fill layer (not too strict)

The density of the bottom fill layer on a 1.3m fill is just below the required time. **Effect:** Low risk, as the loading effect on the layer 1.3m below is minimal. **Decision:** Accept the fill layer with low density, since rejecting the bottom layer could have a huge effect on the programme.

A balance must be reached regarding when to be strict and when to be lenient. The give and take principle must be used; be lenient in one area but strict in another, like where safety is very important.

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For example: grant a concession regarding specification when there is low risk, but require better quality or machines in a task where the risk is high.

Example 24.4: Level of selected layer high (strict)

The level of the selected layer is too high. **Effect:** The next layer, stabilised subbase, will be too thin. This will reduce the overall strength of the pavement structure. **Decision:** Reject selected layer, and either skim off the top of the selected material, or reconstruct the layer.

Discretion must be used when working with emerging contractors:

- Set the standard of quality of work by assisting SMMEs with the first element that is constructed, but give them a chance to construct the rest.
- Give credit for small accomplishments. Build them up, motivate and help them, get the best out of the team. If the standard is still not satisfactory, replace the subcontractor, especially if it influences the progress and critical path of the overall project

Danger: Do not reject work more than twice, it will break their motivation and effort to improve.

Example 24.5: Bell mouth radius (not too strict)

The kerbs at the bell mouth at a minor access road were not constructed with 15m radius but 10m radius. **Effect:** Limited effect if no trucks use the access road. **Decision:** Accept 10m radius if access road is not used by trucks.

24.3.2. BEING TOO LENIENT

Effect of the Resident Engineer being too lenient:

- RE and Site Agent become big buddies
- RE accepts substandard work
- Threats from Contractor influence the RE's decisions.

Conclusion:

- Poor quality and poor standard of work
- Contractor is overpaid, e.g., wastage not subtracted, etc.
- Consultant becomes the puppet that says yes to all requests from the Contractor.

Example 24.6: Seal base with coarse surface (too lenient)

The existing base was stabilised with 2,5% cement. The base is sealed with a 14mm rubber seal. The rubber seal is to prevent any water ingress when the stabilised base cracks, as it has a stretching property.

Although the density, levels, and material properties all comply to the specifications, that surface of the base layer appears coarse. The surface finish looked worse than the existing road that was rehabilitated. This layer also showed defects in the centre line as there was no overlap between the left lane and the right lane.

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It was agreed that the base layer should be extensively patched to improve the surface. A full width slurry was applied to correct the surface texture. Further course sections were repaired using asphalt. These asphalt patches done by hand on large sections appeared very course and uneven.

The method statement and trial section should have been rejected. More trial sections should be constructed until the desired surface texture and finish was accomplished. The layer could be rejected on bad workmanship, *COLTO 8202*. The final cut is to be done with an experienced grader operator. Small holes are to be filled up with moist stabilised material after final cut is done before final rolling.

24.4. Risk and Responsibility

Important: Be strict when there is a high risk or major influence on integrity of the work and lenient when there is a low risk or little effect on the performance of the works.

Examples of low-risk tasks where the Resident Engineer could be more lenient:

- Bell mouths
- Fill material and levels
- Non-structural concrete, e.g., culvert inlet and outlets
- Temporary deviations
- Density at bottom layers

Examples of high-risk tasks where the Resident Engineer needs to be very strict:

- Bridge decks and beams
- Temporary formwork for bridges and big culverts
- Deep excavation in soft, muddy, or unstable material, especially during the rainy season
- Working near power or railway lines
- The finish of a base level that will be covered with a seal
- Density of base layer or asphalt.

There is a risk and responsibility, carried by both the Contractor and the Consultant.

There is a chance of rain, and the contractor asks you, the Resident Engineer, if he may:

- Order asphalt
- Slurry
- Mix rubber bitumen
- Cast concrete base for bridge
- Cast bridge deck with possibility of thunderstorm
- Cast concrete side drains during light drizzle.

If you give permission to go ahead on any of the above activities and there is rain damage, he will hold you responsible because you gave the go ahead. If you say he cannot go ahead and it did not rain, the contractor will claim because you stopped the work. The claim for inclement weather is only applicable if it did rain.

The decision and risk to work or not to work when rain is predicted remains with the contractor.

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24.5. Be Strict but Fair

Ensure a good working relationship with the Contractor by being strict but fair. Find the middle ground or use the give and take principle to find practical solutions to problems. The Contractor should discuss problems without training. The goal is to work together as a team.

Conclusion: Setting a good standard ensures good quality and a good relationship without unnecessary claims.

Example 24.7: Crushed stone bay (strict but fair, give & take)

Case 1: The contractor constructed a crushed stone base trial section. The grading of G3 base material was marginal. The sections were submitted for approval, but the average grading was outside the target grading specification, yet inside the grading specified as G3 stone in COLTO.

Solution: The Engineer approved the trial section by adjusting the target grading to be in specification, thus not using the average grading. The results were monitored.

Case 2: The construction of the G3 base was monitored. The average grading of the G3 base was good, but individual grading was outside the specification. The densities of the base were very high, and level control was very good.

Solution: The Engineer accepted the G3 base in section 1 – 3 where the traffic volumes were very low. The Engineer required another trial section for section four, that has higher traffic volumes. The supplier needed to adjust the sieves.

Conclusion: The supplier replaced some of the sieves. The grading of the new trial section was within specification. Good quality was achieved. Low risk with good density and strength.

Case 3: The Contractor constructed G3 base to a good quality. Rain damage on the base led to poor surface finish in section four. The level was too low in the middle between wheel paths in certain sections. The coarse section at the access road was also rejected with the rain damage and level problems. Contractor proposed to do extensive base repairs on rejected sections, thickness corrections up to 15mm.

Solution: The Resident Engineer did not agree on the extensive repairs. The layer was to be rebuilt or repaired with an asphalt scratch coat.

Conclusion: The standard of the G3 finishing improved. Cutting edges of the grader were checked regularly and replaced when needed. Good quality was maintained, without any bleeding or stripping of the seal.

24.6. Give and Take Principle

Much more is achieved on a site when the Contractor and the Consultant work as a team and implement the give and take principle.

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Mistakes are made by both the Contractor and the Consultant. Instead of working against each other, e.g., the Contractor claiming for every mistake in the document, and the Consultant being unnecessarily strict, it is better for both parties to accommodate these mistakes and work together. It is a give and take principle.

Common flaws/mistakes made by Consultants:

- Drawings, lack of information
- Contradictions between project document, drawings, and the Bill of Quantities
- Unpredicted problems, unknown services, incorrect water table levels, etc.
- No provision made for excavating hard material or unsuitable material
- Mistake on bending schedule
- Mistake on culvert level
- Road levels do not tie into existing layer/bridge deck level
- Late information or occupation of portion of the works.

Mistakes made by the Contractor:

- Unbalanced rates
- Misinterpretation of drawings
- Execution of the works
- Levels too high or too low
- Material from borrow pit inadequate
- Wrong binder type sprayed
- Layer tipped/constructed on top of layer that was not tested/approved
- Densities, borderline or too low
- Samples not taken
- Layers not tested.

Consequences of how the mistakes are handled are as follows:

1. The fight and claim method:
   a. Negative attitude on site
   b. Fights get personal
   c. We all look bad
2. The give and take principle
   a. Working as a team
   b. One hand washes the other
   c. We all look good.

Example 24.8: Level of gravel subbase too low (strict but fair, give & take)

The level of the subbase layer is too low. **Effect:** The next bitumen stabilised layer will be thicker. More bitumen and cement will be required to stabilise the layer as per design. Who will pay for the extra stabilisation? **Decision:** Accept lower level of subbase on the condition that the Contractor will pay for the additional stabilisation, including the additional bitumen required. This ensures that there is no risk to the Client.

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Examples of give and take principles:

Consultant Give Concession / engineering judgement	Consultant Takes Requests correct or improved solution or service without compensation or claims
Mild agreements	
Mark patches minimum 1m wide for 1m wide milling machine.	Tie-in levels with existing road incorrect, issue new levels without claims.
Stabilisation design done in advance, save 2-4 weeks on programme.	Start construction of road in section 2, not in section 3 to allow for moving of services without any claims.
	Construction of side drains after seal with emulsion to prevent stains on the concrete at steep gradients.
More serious agreements	
Accepting prime that is just out of specification.	Filling sandbags placed on delineators with aggregate and not sand. Sandbag broken by traffic. Difficult to remove sand in new seal before slurry for Cape seal.
Soilcrete backfilling at culvert, no testing required.	Construct shoulder widening used as deviation road on the LHS of the road and not RHS, less fill material; programme revised.
Using substandard material for temporary work.	
Extend specified 4km closure to 5km closure for a limited time to catch up on task on critical path.	Construction in half width, construct subbase layer 300mm over centre line and base layer 150mm over centre line to ensure overlap and good joint of G3 base layer.
Working at night, on condition that proper lights are used.	Larger stones dragged during final cut of base. Task labourer to fill holes when doing final cut level, using fine wet stabilised material from the windrow to ensure good smooth level finish.
Waiver of penalties for accommodation of traffic	Replace old shutters for better concrete surface finish.
	Cleaning the shoulder after patching within a week.
Serious agreements	
Use of alternative deviation road, may cost a bit more but easier and safer for Contractor.	Replace old plant with alternative plant, e.g., concrete mixer, distributor, bomag walk behind instead of plate compactor, etc.
	Cover stabilised subbase layer with base layer within 3 days to prevent carbonation.
Acceptance of work outside specification, e.g., grading of G3 base not critical in section 1-3 with low volume traffic	Replace foreman or grader operator to improve quality and progress of work.
Seal in embargo period when night temperatures are still high	Immediate response to an unsafe excavation, or flagman required at a blind rise/corner.

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24.7. Conflict Management

It is difficult for a young engineer on site to earn the respect with limited experience on site. Young engineers experience strain when working with foremen that have been building roads for the past 30 years.

Here are a few tips for managing the conflict on site:

- Pick your fights, argue about tasks and issues that are important and cost money, don't argue about small unimportant issues, it just ruins the relationship unnecessarily.
- Prevent conflict by being proactive. Read and apply the guidance written in this manual. Warn and inform the Contractor about pitfalls and where specifications will be strictly followed. The fight is not so severe when you told the foreman the work will be rejected if this or that was not in place.
- Contractors don't mind rebuilding or repairing any section of the road when the machines are nearby.
- Indicate mistakes and warn about rejection while the contractor is still constructing the layer. Be involved. The Contractor will use the excuse that he is not finished yet. Never mind his excuses or comments, that fact is that you timeously pointed out mistakes and remedial actions are avoided or limited.
- Waiting till the layer is finally submitted for approval, with levels that are submitted late, and then rejecting sections or pointing out repairs is messing the contractor around unduly.

Tip: Use the following phrases to manage conflict, especially if a young engineer works with an old, experienced foreman: *"The Engineer Mr. So-and-so will not approve this"* instead of you rejected the works or say, *"Would you accept this standard when it is constructed at your house?"*

If a Contractor bluntly refuses or ignores an instruction, say the following: *"I don't care what you do, but you will only get paid what we ask for".* If a foreman or person continues to ignore instructions, have the person removed from site. Discuss this at a higher level with the Engineer and Project Manager before implementing.

Refer to *General Conditions of Contract clause 24.*

Example 24.9: Asphalt production (pro-active)

Asphalt production for the last two weeks was 400 tons per day and all within specification. The binder of the asphalt was too high the previous day. It rained two days ago. **Effect:** A lot of asphalt could be rejected if the binder remains out of specification. **Decision:** The Resident Engineer must reduce asphalt production to 50tons per day over the next two days to limit the risk. The binder application rate must be adjusted to compensate for moisture (bulking) of crusher dust used in the asphalt mix. This saved the contractor R1,2 million of asphalt that would have been produced at full capacity. Accepting out of specification binder with reduced payment with a mix design that is suspect was too risky.

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24.8. Key Success Factors

24.8.1. SUCCESS OF PROJECT

The success of a project is measured by the following:

- Complete within budget
- Complete within time
- Good quality
- No serious injuries or fatalities

The order of importance may differ for each role player in the project.

24.8.2. CONTRADICTIONS TO THE SUCCESS OF A PROJECT

Many successes are negated by inadequate attention to detail:

- Job creation, without quality – may as well pay unemployed labour without doing anything.
- SMME opportunities without development of management capabilities, and financial calculations.
- Training without continuation.
- Good quality but with fatalities, roads could be rebuilt but lives could not be replaced.
- Good relationships with contractor (friends) but poor quality or little value for money.

24.8.3. KEY SUCCESS FACTORS FOR A PROJECT

Key success factors for a project:

- Relationship between Site Agent and Resident Engineer
- Strict first & lenient later = good relationship.
- Use engineering judgement
- Balance between being strict and lenient; applying the give and take principle.

24.8.4. TRAITS OF A GOOD RESIDENT ENGINEER

The Resident Engineer determines the quality on the project and, to a large extent, the success of the project.

Traits of a good Resident Engineer (Key Success Factors):

1. Never trust a contractor, check dips, levels, cement bags etc. yourself.
2. Confirm verbal instructions in writing, site instruction or email.
3. Follow through with site instructions to the lowest level! Make sure the foreman, operator, and local worker knows about the relevant site instruction you issued.
4. Set the standard early, 'initiate' first confrontation on important issue.
5. Have your big fight right at the beginning of the project, then you'll end as friends.
6. Don't nit-pick, choose your fights. Focus on the important issues. Keep the relationship healthy.
7. Be consistent, don't deny what you said or change your instruction all the time.
8. Be strict but fair.
9. Don't lose your cool; you won't be respected.
10. Have a technical meeting before any team starts; clearly explain the requirements.
11. Be proactive, warn contractor in advance; when things go wrong, the fight won't be as severe.
12. Keep a personal diary.

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24.9. Application On Site

It is strongly recommended that this manual is used and explained by an experienced mentor working on a road construction or civil engineering project in South Africa. Skills Transfer South Africa can help facilitate such a mentorship process through an 18-month e-learning course with 30miin weekly online lectures/assistance, followed by writing tests, doing assignments on site, and submitting them for assessment. The suite of spreadsheets referred to in the course will be made available and explained as relevant per module.

A certificate for level 1 to 4 could be obtained for each module that is successfully completed. The curriculum could be completed over multiple projects.

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APPENDICES

APPENDIX A: QUALITY CONTROL PLAN

CONSULTANT	QUALITY CONTROL PLAN	Rehabilitation & Reseal of Roads Contract no. C1000 Ref : Date :

Section: All — Also refer Project Specification :

Section: Road Works

Key: IRB - Inspection Request Book; RE - Resident Engineer; W - Witness; H - Hold point (not to proceed without written approval); S - Surveyor; R - Request inspection; LDT - Production for the day; SR - Submit Results

Note : Witness (W), Test (T) and Hold (H) Points as indicated on Inspection and Test plans are to be recorded in the Inspection and Test Request Book.

Item No	Activity	Commencement Criteria, Specification and Standard Reference	Frequency	Record Type	Intervention levels RE	CON	SA	Remarks
1	**Clearing & Grubbing (COLTO 1100)**							
1.1	Clearing and grubbing	COLTO 1703	Initial		H	R	W	
1.2	Clearing and grubbing alongside services/fences of Hydraulic structures	COLTO 1703	Initial		W	R	W	
1.3	Clearing out of temporary diversions	COLTO 1703	Initial		W	R	W	
2	**Prefabricated culverts/pipes (COLTO 2300)**							
2.1	Method statement	COLTO 15.03 a	Initial		H		H	
2.2	Survey/Setting out	COLTO 1206	Each culvert		W	R	W	
2.3	Excavate for prefabricated culvert and inspect foundation	COLTO 2303 & 2310	Each culvert		H	R, SR	W	
2.4	Place and test bedding for prefabricated culverts/pipes	COLTO 2312 & 2313	Each culvert		H	R, SR	W	Density
2.5	Place prefabricated culverts/pipe on and joint units	COLTO 2312	Each culvert		H	R	W	
2.6	Appendages							
2.6.1	Inspect concrete work - Pre Concrete Inspection	COLTO 2313, 6200,6300 & 6400	Each pour		H	R	W	Submit Mix Designs
2.6.2	Take cubes and slump		Each pour		W	SR	W	
2.6.3	Inspect concrete work - Post Pour Check (Inspection)		Each culvert		H	R	W	
2.7	Head & Wing walls							
2.7.1	Inspect concrete work - Pre Concrete Inspection	COLTO 2313, 6200,6300 & 6400	Each pour		H	R	W	Submit Mix Designs
2.7.2	Take cubes and slump		Each pour		W	SR	W	
2.7.3	Inspect concrete work - Post Pour Check (Inspection)		Each culvert		H	R	W	
2.8	Check levels (Inlet & Outlet)	COLTO 2702	Each culvert		H	S, SR	W	Submit levels
2.9	Backfill in layers, compact, trial trench & final inspection	COLTO 2711	Each Culvert		H	R, SR	W	Density, Proof rolled
3	**Mass Earthworks (COLTO 3300)**							
3.1	Setting out	COLTO 1203	At start			S		
3.2	Roadbed under fills (preparation & compaction)	COLTO 3303, 3305, TMH 5	Each Section		H	R, SR	W	Levels, Densities, Proof rolled
3.3	Fills - place each layer, Compact to 98%	COLTO 3703, 3305, TMH 5	Each Lot		H	R, SR	W	Levels, Densities, Proof rolled
3.5	Cuts - formation to minimum level to lay selected, density testing & compaction	COLTO 3306 (a) & 3305, TMH 5	Each Lot		H	R, SR	W	Levels, Proof rolled
4	**Impact rolling (Project specification Part E)**							
4.1	Method statement	COLTO 15.03 a	Initial		H		H	
4.2	Preparation of road surface before rolling	Project specification PE	Each Lot		H	R	W	
4.3	Impact compaction	Project specification PE	Each Lot		H	R	W	Continuous impact response, DCP, Density
5	**Pavement layers of Gravel Material Type(COLTO 3100) & Stabilised Gravel Material Type (COLTO 3300)**							
5.1	Setting out	COLTO 1206	At start			S		
5.2	Method statement	COLTO 15.03 a	Initial		H		H	
5.3	Gravel wearing course	COLTO 3400	Each Lot		H	SR	H	Levels, Densities, Proof indicator, Layer Thick
5.6	Selected, Cut & Fraud indicator	COLTO 3400	Each Lot		H	R, SR	H	Levels, Densities, Proof indicator, Layer Thick
5.9	Rolling extra, notional at 3 km of lacing	COLTO 3400	each Lot		H	R	H	Dy tests, Proof indicator, CBR
5.10	Subbase: DBM, LCB, Fraud indicator & B2	COLTO 3400 & 3300	Each Lot		H	R, SR	H	Levels, Densities, Proof indicator, Layer Thick
5.13	Check Curing	COLTO 3600	Each Lot		H	R		
6	**Pavement layers of Gravel or Crushed Stone (COLTO 3600)**							
6.1	Submit Material Properties	COLTO 3402	On Request		H	SR	W	Rock Type, Grading, AIV, FI, Attenuy
6.2	Method statement	COLTO 15.03 a	Initial		H		H	
6.3	Check underlying layer for tolerance & place licensed material	COLTO 3600 (b)	Each Lot		H	R	W	
6.4	Compact and check moisture, density and other properties	COLTO 3300	Each Lot		H	R, SR	W	
6.5	Check levels, layer Thickness & finished width	COLTO 3300	Each Lot		H	S, SR	W	Levels, Densities, Layer Thick
6.8	Test for Double Seal Design	TRH 3	Each Lot		H	SR	W	Sand Patch, Texture Depth, Ball Penetration
7	**Patching (COLTO 3800)**							
7.1	Submit Mix Design and method statement	COLTO 4202 (b)	Initial		H	R	W	Cumulative 9/10/07 and 8/08/07
7.2	Method statement	COLTO 15.03 a	Initial		H		H	
7.3	Area patch							
7.3.1	Perception of material, check depth	COLTO 3804 c	Each Patch		H	R	H	
7.3.2	Compact excavation floor	COLTO 3804 c	Each Patch		H	R	H	
7.3.3	Mixing, backfill and compaction	COLTO 3804 d	Each Patch		H	R, SR	H	Check density, test density, seal indicator
7.3.4	Appraisal of base patch	COLTO 3804 d	Each Patch		H	R	H	
7.4	Surface patch							
7.4.1	Milling out existing bituminous materials and cleaning	COLTO 3805 b						
7.5	Check underlying layer for tolerance	COLTO 3402 (c)(i)	Initial		H	R	H	
7.6	Applying Tack Coat	COLTO 3402 (c)(ii)	Each Portion		H	R	H	
7.7	Placing Asphalt	COLTO 4207	Each Lot		H	R, SR	H	Density, grading, binder content, voids
7.8	Appraisal of Asphalt Surfacing	COLTO 4210	Each Lot		H	R	H	
9	**Prime (COLTO 4100)**							
9.1	Survey/Setting out	COLTO 1206	Each spray			S		
9.2	Check underlying layer for tolerance, moisture content, etc.	COLTO 3100 & 4100	Before priming		H	R, SR	H	
9.3	Nominate required application rate type of primer to be used	COLTO 4105	Initial		H	R	H	
9.4	Spray prime on road and materials spray rate	COLTO 4105 & 4106	Each spray		H	R	H	Rounds, screw rates and submit
9	**Asphalt (COLTO 4200)**							
9.1	Submit Mix Design	COLTO 4202 (b)	Initial		H	R	W	Cumulative 8/4/2007 and 6/8/2007
9.2	Check underlying layer for tolerance	COLTO 3100 (c)(i)	Initial		H	R	H	
9.3	Applying Tack Coat	COLTO 3402 (c)(ii)	Each Portion		H	R	H	
9.4	Placing Asphalt	COLTO 4207	Each Lot		H	R, SR	H	Density, grading, binder content, voids
9.5	Appraisal of Asphalt Surfacing	COLTO 4210	Each Lot		H	R	H	
10	**Surfacing - Double Seal (COLTO 4500)**							
10.1	Tests on seal stone	COLTO 4202 (c), TRH 3	Initial		H	SR	W	AIV, FI, Grading, WCV, PSV
10.2	Approve seal design	COLTO 4302 & 4502	Initial		H		H	Cumulative 08/07
10.3	Method statement	COLTO 15.03 a	Initial		H		H	
10.4	Prepare prime, inspect for damage, report according to approved work	COLTO 4107 & 4206	Each portion		H	R	H	Moisture Content
10.5	Apply tack coat, appropriate & determine rate & spread	COLTO 4303 (a)	Each spray		H	R	H	Rounds, screw rates, test adhering point
10.6	Rolling of the aggregate 3 sets of appropriate pressure, part area of	COLTO 4306 (b), (c) & 4503(e)	Rolling		W	R	W	
10.7	Prepare and remove all excess stone chippings	COLTO 4306 (c) & 4503(e)	Final		W	H	W	
10.8	Exclusive spray rate for first application of binder and if necessary	COLTO 4303 (d)	Each spray		H	R, SR	H	
10.9	Apply second application of binder as before, appropriate (Hot/Cold)	COLTO 4303 (d), R 4503(e)	Each spray		H	R	H	Rounds, screw rates
10.10	Final rolling of the aggregate	COLTO 4306 (c) & 4503(e)	Final		W		W	
10.11	Prepare and remove all excess stone chippings	COLTO 4306 (c) & 4503(e)	Final		W	R	W	
10.12	Apply fog spray if required	COLTO 4403 (c)	Each spray		H	H	W	Rounds, screw rates
10.13	Approval of Seal	COLTO 4503	All		H	R	H	Screening point, visual bleeding / chipping, loss
11	**Slurry (COLTO 4600)**							
11.1	Tests on slurry aggregates	COLTO 4202 (b)	Initial		H	SR	W	Grading
11.2	Approve slurry design mix, and sample	COLTO 4302 & 4504	Initial		H		H	Cumulative 08/07
11.3	Clean all dirt, dust and any oil on surface	COLTO 4304 (c)	Each section		H	R	H	
11.4	Check surface, apply tack coat	COLTO 4304 & 4503 (c)	Each lot		H	R	H	Rounds, slump and thickness, worksheet
12	**Edge beams (COLTO 3135)**							
12.1	Inspect concrete work - Pre Concrete Inspection		Each pour		H	H	W	Submit Mix Designs
12.2	Take cubes and slump	3135, 6100, 6200 & 6400	Each pour		W	SR	W	
12.3	Inspect concrete work - Post Concrete Inspection		Each pour		H	R	W	
13	**Guardrails (COLTO 3100)**							
13.1	Setting out / type of guard rail	COLTO 1701	Initial		W	R	W	
13.2	Pre-pave and inspect	COLTO 1701, 3101	Each Installed		H	R	W	
13.3	Material Selection	COLTO 3102	Initial		H	R	W	
13.4	Basket Construction	COLTO 3102	Initial		H	H	W	
13.5	Inspection of Barrier painting and Reseal	COLTO 3103	Each Installed		H	H	W	
13.6	Inspect completed work	COLTO 3101	Each Installed		H	R	W	
14	**Guardrails (COLTO 3400)**							
14.1	Setting out for guard rails	Drawings	Each section		H	R	W	
14.2	Inspect all materials on delivery and ensure compliance with Spec for	COLTO 3402	As delivered		W	R	W	
14.3	Install rail, complete fixings, bolts etc & check levels/level	COLTO 3403 (a)	Each section		H	R	W	
14.4	Backfill holes for posts and compact	COLTO 3403 (a)	Each section		W	R	W	
14.5	Inspect completed work & fills and accept work from Sub-contractor	COLTO 3404	Each section		H	R	W	
15	**Fencing (COLTO 3600)**							
15.1	Setting out	COLTO 1206	At start			S		
15.2	Clear and grub fence line	COLTO 3609	Routine		W	R	W	
15.3	Inspect completed fence and accept work from Sub-contractor		Each section		H	R	H	
17	**Roadsigns (COLTO 4800)**							
17.1	Survey, Setting out	Drawings			H	R	W	
17.2	Excavation and Concrete Bases	Drawings			H	R	W	As-bes Application
18	**Road marking (COLTO 5700)**							
18.1	Pre mark the road markings. Review prior to road marking	COLTO 5706	All markings		W	R	W	
18.2	Inspect completed road marking and accept work from Sub-contractor	COLTO 5710(c)			H	R	W	
19	**Final inspection on sections of road completed**		Each section		H	R	H	Snag List

QCP Approval:
1. QCP Prepared by: Position: RESIDENT ENGINEER Signed: _____ Date: _____
2. QCP Approved by: Position: PROJECT LEADER Signed: _____ Date: _____

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APPENDIX B: REGISTERS

Appendix B1: Miscellaneous Register

Consultant	INSPECTION REQUEST REGISTAR MISCELLANEOUS	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C1000	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor								Engineer						
	Inspection request to be submitted by 16h00 for the next day								Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)						
	Date	Road	Inspection required	Location	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Survey	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
GN001															
GN002															
GN003															
GN004															
GN005															
GN006															
GN007															
GN008															
GN009															
GN010															
GN011															
GN012															
GN013															
GN014															
GN015															
GN016															
GN017															
GN018															
GN019															
GN020															

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Appendix B2: Concrete Register

Consultant	INSPECTION REQUEST REGISTAR CONCRETE	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C1000	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor										Engineer						
	Inspection request to be submitted by 16h00 for the next day										Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)						
	Date	Road	Structure	Unit	Inspection	Location	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Levels	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
CC001																	
CC002																	
CC003																	
CC004																	
CC005																	
CC006																	
CC007																	
CC008																	
CC009																	
CC010																	
CC011																	
CC012																	
CC013																	
CC014																	
CC015																	
CC016																	
CC017																	
CC018																	
CC019																	
CC020																	

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Appendix B3: Culvert and Services Register

Consultant	INSPECTION REQUEST REGISTAR CULVERTS & SERVICES	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C10001	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor										Engineer						
	Inspection request to be submitted by 16h00 for the next day										Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)						
	Date	Road	Culvert		Inspection	Location	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Levels	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
PC001																	
PC002																	
PC003																	
PC004																	
PC005																	
PC006																	
PC007																	
PC008																	
PC009																	
PC010																	
PC011																	
PC012																	
PC013																	
PC014																	
PC015																	
PC016																	
PC017																	
PC018																	
PC019																	
PC020																	

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Appendix B4: Layer Works Register

Consultant	INSPECTION REQUEST REGISTAR LAYER WORKS	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C1000	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor										Engineer						
	Inspection request to be submitted by 16h00 for the next day										Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)						
	Date	Road	Layer	Class	Start	End	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Levels	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
LW001																	
LW002																	
LW003																	
LW004																	
LW005																	
LW006																	
LW007																	
LW008																	
LW009																	
LW010																	
LW011																	
LW012																	
LW013																	
LW014																	
LW015																	
LW016																	
LW017																	
LW018																	
LW019																	
LW020																	

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Appendix B5: Crushed Stone Register

Consultant	INSPECTION REQUEST REGISTAR CRUSHED STONE	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C1000	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor										Engineer						
	Inspection request to be submitted by 16h00 for the next day										Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)						
	Date	Road	Layer	Class	Start	End	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Levels	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
C 5001																	
C 5002																	
C 5003																	
C 5004																	
C 5005																	
C 5006																	
C 5007																	
C 5008																	
C 5009																	
C 5010																	
C 5011																	
C 5012																	
C 5013																	
C 5014																	
C 5015																	
C 5016																	
C 5017																	
C 5018																	
C 5019																	
C 5020																	

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Appendix B6: Prime, Seal, Fog Spray Register

Consultant	INSPECTION REQUEST REGISTAR SEAL	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C10001	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor										Engineer					
	Inspection request to be submitted by 16h00 for the next day										Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)					
	Date	Road	Seal type	Binder	Start	End	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
SE001																
SE002																
SE003																
SE004																
SE005																
SE006																
SE007																
SE008																
SE009																
SE010																
SE011																
SE012																
SE013																
SE014																
SE015																
SE016																
SE017																
SE018																
SE019																
SE020																

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Appendix B7: Slurry Register

Consultant	INSPECTION REQUEST REGISTAR SLURRY	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C1000	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor										Engineer						
	Inspection request to be submitted by 16h00 for the next day										Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)						
	Date	Road	Layer	Slurry Grading	Start	End	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Level/ Thickness	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
SL001																	
SL002																	
SL003																	
SL004																	
SL005																	
SL006																	
SL007																	
SL008																	
SL009																	
SL010																	
SL011																	
SL012																	
SL013																	
SL014																	
SL015																	
SL016																	
SL017																	
SL018																	
SL019																	
SL020																	

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Appendix B8: Asphalt Register

Consultant	INSPECTION REQUEST REGISTAR ASPHALT	Contractor: Contractor A Laboratory: Laboratory B	BOOK no. 1
CONTRACT no: C1000	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)		

Request no.	Contractor										Engineer						
	Inspection request to be submitted by 16h00 for the next day										Accepted (√), Rejected (x), Partial payment (PP), Repairs required (RR), Resubmit (RS)						
	Date	Road	Layer	Asphalt Grading	Start	End	LHS RHS	Requested by	REQUIRED DATE	REQUIRED TIME	Level/ Thickness	Material	Visual	Accepted Rejected	Remarks	Date	Engineer
A 0001																	
A 0002																	
A 0003																	
A 0004																	
A 0005																	
A 0006																	
A 0007																	
A 0008																	
A 0009																	
A 0010																	
A 0011																	
A 0012																	
A 0013																	
A 0014																	
A 0015																	
A 0016																	
A 0017																	
A 0018																	
A 0019																	
A 0020																	

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Appendix B9: Non-Conformance Register

Consultant	NON-CONFORMANCE REPORT REGISTER				Contractor: Contractor A Laboratory: Laboratory B		BOOK no. 1
CONTRACT no: C1000	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)						
NCR No.	Request no.	POSITION AND DESCRIPTION OF NON-CONFORMANCE	CORRECTIVE ACTION AGREED	DATE ISSUED	ISSUED BY	DATE CLOSED	SIGN
NCR001							
NCR002							
NCR003							
NCR004							
NCR005							
NCR006							
NCR007							
NCR008							
NCR009							
NCR010							
NCR011							
NCR012							
NCR013							
NCR014							
NCR015							
NCR016							
NCR017							
NCR018							
NCR019							
NCR020							

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APPENDIX C: LABORATORY TEST REQUEST – SOILS

Consultant	TEST JOB REQUEST SITE LAB LAYERWORKS	Laboratory

CONTRACT No. C1000

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

Road	From	To	Lane	Length (m)	Width (m)	Thick (mm)	Area (m2)	m3
MR531	80000	81000	LHS	1000	4.00	150	4000	600
Total				1000			4000	600

REQ NO: LW086

LAYER: Subbase

Description: Lane

SOURCE: In-situ

TEST DATA

Ready for samples	20-May-21	Time	10h00	Number of tests	10	Block length	100.0

Test Position				Type of test							
No	Random	Chainage	Offset	Density	MOD	Indicator	CBR	UCS	ITS	DCP	
1	0.849	80085	0.7	x							
2	0.884	80188	2.0	x	x	x		x	x		
3	0.772	80277	2.2	x							
4	0.777	80378	2.5	x		x		x	x		
5	0.493	80449	2.8	x		x		x	x		
6	0.127	80513	2.0	x							
7	0.495	80649	0.5	x	x	x	x	x	x		
8	0.697	80770	2.0	x							
9	0.620	80862	3.1	x		x		x	x		
10	0.547	80955	3.1	x		x		x	x		
11	0.507										
12	0.186										

REMARKS

Requested by:				Received by laboratory manager:				Sign
Date:		Time:	16h00	Date		Time:	16h00	

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APPENDIX D: LABORATORY TEST REQUEST – ASPHALT

Consultant	TEST JOB REQUEST SITE LAB ASPHALT	Laboratory

CONTRACT No. C1000

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

Road	From	To	Lane	Length (m)	Width (m)	Thick (mm)	Area (m2)	tons
MR531	87000	87500	LHS	500	4.00	40	2000	196
Total				500			2000	196

REQ NO: AS002

LAYER: Surface

Asphalt Grade: Contineous Medium

SOURCE: Plant AC

TEST DATA

Ready for samples	20-May-21	Time	10h00	Number of tests	5	Block length	100.0

Test Position				Type of test							
No	Random	Chainage	Offset	Density	Marshall	Binder	Grading	Sand Equiv.			
1	0.691	87069	0.2	x		x	x				
2	0.135	87113	3.6	x							
3	0.638	87264	3.0	x	x	x	x	x			
4	0.788	87379	1.1	x							
5	0.334	87433	2.4	x	x	x	x				
6	0.044										
7	0.191										
8	0.593										
9	0.277										
10	0.739										
11	0.904										
12	0.047										

REMARKS

Requested by:				Received by laboratory manager:			
Date:		Time:	16h00	Date		Time:	16h00

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APPENDIX E: INSPECTION REQUESTS

Appendix E1: Miscellaneous Inspection Request

Consultant	INSPECTION REQUEST	ST001	Req no.
	MISCELLANEOUS	Rev 1	GEN001

CONTRACT no: C1000 CONTRACTOR: Contractor A

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

INSPECTION REQUIRED:

Date _____ Time _____

Location:

LAB TESTS REQUIRED		SURVEY REQUIRED		Quantity
		Setting out		As built
		Inspection		Re-check

Requested by Contractor: _____ Sign _____ Date _____ Time _____

Received by RE/CoW: _____ Sign _____ Date _____ Time _____

Received by surveyor: _____ Sign _____ Date _____ Time _____

Received by Lab: _____ Sign _____ Date _____ Time _____

Test results submit by: _____ Sign _____ Date _____ Time _____

Survey submit by: _____ Sign _____ Date _____ Time _____

VISUAL INSPECTION

Visual inspection done by: Sign Date

Comments: _____

RESIDENT ENGINEER

Attach documents: Test results, Evaluation of test results, Survey Levels/Quantities, Checklist with visual inspection sheet

Accept ✔ Reject X, Partial payment (PP)
Retest (RT), Repair (RR), Resubmit (RS)

Visual	Survey	Material	Other tests

Comments / Action section uired by Contractor: _____

Permission to continue with next action: _____

Contractor: _____ Position: _____ Sign _____ Date _____

Consultant: _____ Position: _____ Sign _____ Date _____

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Appendix E2: Concrete Inspection Request

Consultant	INSPECTION REQUEST	ST002	Req no.
	CONCRETE	Rev 1	CC001

CONTRACT no: C1000	CONTRACTOR: Contractor A
Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)	

Concrete class 25/19 Source Plant C

LOCATION				DESCRIPTION		INSPECTION		ENGINEER
No	*Road*	*Km*	*Lane*	*Structure*	*Element*	*Inspection*	*Volume*	*Visual inspection*
1								
2								
3								
4								
5								
6								

Total cubes 0 m3 **Inspection ready at:** Date _____ Time _____

Requested by Contractor: _____ Sign _____ Date _____ Time _____

Received by RE/CoW: _____ Sign _____ Date _____ Time _____

Received by Lab: _____ Sign _____ Date _____ Time _____

CONCRETE CORE TESTS	3 days	7 days	28 days	48 days	Cores
Number of cube tests					

Test results submitted to: _____ Sign _____ Date _____ Time _____

Survey submitted to: _____ Sign _____ Date _____ Time _____

ACCEPTANCE

Visual inspection done by: _____ Sign _____ Date _____

Comments / Action sectionuired by Contractor: _____

☐ Accepted ☐ Conditinal Acceptance ☐ Remedial work ☐ Rejected

Permission to continue with next action: _____

Engineer: _____ Position: _____ Sign _____ Date _____

Contractor: _____ Position: _____ Sign _____ Date _____

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Appendix E3: Culverts and Services Inspection Request

Consultant	INSPECTION REQUEST	ST026	Req no.
	CULVERTS & SERVICES	Rev 1	PC001

CONTRACT no: C1000 CONTRACTOR: Contractor A

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

INSPECTION								LAB TEST		ENGINEER
No	*Road*	*Km*	*Lane*	#	*Size*	*Length*	*Description*	*MOD*	*Density*	*Level, alignment*
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Total Length 1200m Inspection ready at: Date _____ Time _____

Requested by Contractor: _____ Sign _____ Date _____ Time _____

Received by RE/CoW: _____ Sign _____ Date _____ Time _____

Received by surveyor: _____ Sign _____ Date _____ Time _____

Received by Lab: _____ Sign _____ Date _____ Time _____

Levels submitted to: _____ Sign _____ Date _____ Time _____

Test results submitted to: _____ Sign _____ Date _____ Time _____

VISUAL

Visual inspection done by: _____ Sign _____ Date _____

Comments / Action sectionuired by Contractor: _____

RESIDENT ENGINEER

See attach evaluation sheet. Accepted ☐ Conditinal Acceptance ☐ Rejected ☐

Permission to continue with next action: _____

Name: _____ Position: R.E. Sign _____ Date _____

Name: _____ Position: Site Agent Sign _____ Date _____

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Appendix E4: Layer Works Inspection Request

Consultant	INSPECTION REQUEST	ST003	Req no.
	LAYERWORKS	Rev 1	LW001

CONTRACT no: C1000 CONTRACTOR: Contractor A

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

Layer		Class		Stabilise			Source	
No	*Road*	*Start km*	*End km*	*Lane*	*Length*	*Width*	*Depth*	*Description*
1								
2								
3								
4								

Total Length Volume **Inspection ready at:** Date _____ Time _____

Requested by Contractor: _____ Sign _____ Date _____ Time _____

Received by RE/CoW: _____ Sign _____ Date _____ Time _____

Received by Lab manager: _____ Sign _____ Date _____ Time _____

VISUAL INSPECTION

Visual inspection done by: _____ Sign _____ Date _____

☐ Accepted ☐ Rejected ☐ Remedial work required

Comments / Action sectionuired by Contractor: _____

LEVELS

Survey results submitted by: _____ Sign _____ Date _____ Time _____

☐ H90 ☐ D90 ☐ Accepted ☐ Rejected ☐ Remedial work required

MATERIALS

Test results submitted by: _____ Sign _____ Date _____ Time _____

	Visual	Density	Grading	PI	CBR	UCS/ITS	Levels	Thick	Irregularities	Other
Results										

RESIDENT ENGINEER

Attach documents: Test results, Evaluation of test results, Survey Levels/Quantities, Checklist with visual inspection sheet.

Comments: _____

Permission to continue with next layer/surfacing: _____

Engineer: _____ Position: _____ Sign _____ Date _____

Contractor: _____ Position: _____ Sign _____ Date _____

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Appendix E5: Crushed Stone Inspection Request

Consultant	INSPECTION REQUEST	ST003	Req no.
	CRUSHED STONE	Rev 2	CS001

CONTRACT no: C1000	CONTRACTOR: Contractor A
Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)	

Layer			Class		Stabilise			Source
No	*Road*	*Start km*	*End km*	*Lane*	*Length*	*Width*	*Depth*	*Description*
1								
2								
3								
4								

Total Length Volume **Inspection ready at:** Date _____ Time _____

Requested by Contractor: _____ Sign _____ Date _____ Time _____

VISUAL INSPECTION

Visual inspection done by: _____ Sign _____ Date _____

☐ Accepted ☐ Rejected ☐ Remedial work required

Comments / Action sectionuired by Contractor: _____

LEVELS

Verified by: _____ Sign _____ Date _____ Time _____

Comments: _____

MATERIALS

Verified by: _____ Sign _____ Date _____ Time _____

Comments: _____

ACCEPTANCE

Attach documents: Test results, Evaluation of test results, Survey Levels/Quantities, Checklist with visual inspection sheet

☐ Accepted ☐ Rejected ☐ Reduce payment ☐ Repair ☐ Retest

Comments: _____

Permission to continue with next layer/surfacing: _____

Engineer: _____ Position: _____ Sign _____ Date _____

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Appendix E6: Seal Inspection Request

Consultant	INSPECTION REQUEST	ST005	Req no.
	SEAL	Rev 1	SE001

CONTRACT no: C1000 — CONTRACTOR: Contractor A

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

Seal					Binder			Description
No	*Road*	*Spray*	*Start km*	*End km*	*Lane*	*Length*	*Width*	*Area*	*Remarks*
1									
2									
3									
4									
Total									

Total Length _____ Liters Inspection ready at: Date _____ Time _____

Requested by Contractor: _____ Sign _____ Date _____ Time _____

Received by RE/CoW: _____ Sign _____ Date _____ Time _____

TEST REQUIRED		Spec	Result / Comment	TEST REQUIRED		Spec	Result / Comment
Viscosity				Recovery			
Residual BC				Resilience			
Softening pt				Flow			

Received by Lab manager: _____ Sign _____ Date _____ Time _____

Test results submitted to: _____ Sign _____ Date _____ Time _____

VISUAL INSPECTION

Visual inspection done by: _____ Sign _____ Date _____

☐ Accepted ☐ Rejected ☐ Remedial work required

Comments / Action sectionuired by Contractor: _____

RESIDENT ENGINEER

Comments / Action sectionuired by Contractor: _____

Permission to continue with next layer/surfacing: _____

Name: _____ Position: R.E Sign _____ Date _____

Name: _____ Position: Site Agent Sign _____ Date _____

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Appendix E7: Slurry Inspection Request

Consultant	INSPECTION REQUEST	SL005	Req no.
	SLURRY	Rev 1	SL001

CONTRACT no: C1000 — CONTRACTOR: Contractor A

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

Seal					Binder				Description
No	*Road*	*Spray*	*Start km*	*End km*	*Lane*	*Length*	*Width*	*Area*	*Remarks*
1									
2									
3									
4									
Total									

Total Length _____ Liters Inspection ready at: Date _____ Time _____

Requested by Contractor: _____ Sign _____ Date _____ Time _____

Received by RE/CoW: _____ Sign _____ Date _____ Time _____

TEST REQUIRED		Spec	Result / Comment	TEST REQUIRED		Spec	Result / Comment
Binder				Flow			
Grading				Thickness			

Received by Lab manager: _____ Sign _____ Date _____ Time _____

Test results submitted to: _____ Sign _____ Date _____ Time _____

VISUAL INSPECTION

Visual inspection done by: _____ Sign _____ Date _____

☐ Accepted ☐ Rejected ☐ Remedial work required

Comments / Action sectionuired by Contractor: _____

RESIDENT ENGINEER

Comments / Action sectionuired by Contractor: _____

Permission to continue with next layer/surfacing: _____

Name: _____ Position: R.E Sign _____ Date _____

Name: _____ Position: Site Agent Sign _____ Date _____

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Appendix E8: Asphalt Inspection Request

Consultant	INSPECTION REQUEST	ST004	Req no.
	ASPHALT	Rev 2	AS001

CONTRACT no: C1000 CONTRACTOR: Contractor A

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

Layer		Grade		Binder		Source		
No	*Road*	*Start km*	*End km*	*Lane*	*Length*	*Width*	*Depth*	*Visual remarks*
1								
2								
3								
4								

Total Length Tons **Inspection ready at:** **Date** _____ **Time** _____

Requested by Contractor: _____ Sign _____ Date _____ Time _____

Received by RE/CoW: _____ Sign _____ Date _____ Time _____

Received by Lab manager: _____ Sign _____ Date _____ Time _____

VISUAL INSPECTION

Visual inspection done by: _____ Sign _____ Date _____

☐ Accepted ☐ Rejected ☐ Remedial work required

Comments / Action sectionuired by Contractor: _____

MATERIALS

Test results submitted by: _____ Sign _____ Date _____ Time _____

Evaluation done by: _____ Sign _____ Date _____ Time _____

Visual	Density	Binder	Voids	Other tests

Accept	Reject	Uncertain

Comment: _____

ACCEPTANCE

Comments / Action sectionuired by Contractor: _____

Permission to continue with next layer/surfacing: _____

Name: _____ Position: _____ Sign _____ Date _____

Name: _____ Position: _____ Sign _____ Date _____

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APPENDIX F: NON-CONFORMANCE FORM

	CHIBUTO TO CHONGOENE SHOULDER REHABILITATION	NON-CONFORMANCE REPORT (NCR)

NCR NO :	**CONTRACT NO: 66/OBR-RE/DEN/2001**
PERSON REPORTING NCR :	
REQUEST NO :	**DATE OF REQUEST :**

_____ _____
SIGNATURE OF RESPONSIBLE PERSON DATE

_____ _____
RECEIVED BY CONTRACTOR (NAME AND SIGNATURE) DATE

SECTION OF WORK INSPECTED (DETAILS AND POSITION)

.....
.....
.....
.....

Was the relevant checklist submitted: YES ..... NO ..... N/A .....
Is there any connection between this non-conformance and any item on the checklist: YES.....NO..... N/A .....

DESCRIPTION OF THE NON-CONFORMANCE

.....
.....
.....
.....
.....

Relevant SATCC clause in terms of which NCR is issued:

CORRECTIVE ACTION AGREED

.....
.....
REWORK AND RE-SUBMIT .....
.....
.....

_____ _____
SIGNATURE OF CONTRACTOR DATE

DISPOSAL

☐ **Repair / Rework / Replace** (refer to Corrective Action)

☐ **Application for a concession**

☐ **Accept with Concession**

☐ **Reject Concession**

☐ **Non-Conformance closed-off**

The following information to be completed for record purposes (if applicable)

Site Instruction no: .....

Reference no of letter: .....

Concession no: .....

....
SIGNATURE OF RESIDENT ENGINEER DATE

FILE NO :	DISTRIBUTION :

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APPENDIX G: STATISTICAL ANALYSIS – STABILISATION

Consultant	LAYER WORK EVALUATION

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

CONTRACT No: C1000		CONTRACTOR: Contractor A	
DATE:	01 June 2016	TEST REQUEST FORM TR No.	CIR016

ROAD No.	R503/1	from km:	68.620	to km:	68.680	RHS
LAYER	Base	Thickness	160 mm	Source	In-situ	
CLASS	BSM3	% STABILISING		1 % cement	2% emulsion	

MOD(kg/m³)	2050	2077					LEVEL	D90	
OMC %	7.5	7.0						H90	

No	Outlier	Density	MC	GM	PI:	UCS	ITS_{dry}	ITS_{wet}	Sieves	Grading	Spec
1	no	100.0	6.1	2.1	2	1106	206	97	75mm	100	100
2	no	100.6	6.0	2.0	4	1052	203	88	63mm	100	100
3	no	100.9	6.0						50mm	100	100
4	no	99.4	5.9						37.5mm	100	100
5	no	99.9	6.2						28mm	99	82 - 100
6	no	100.2	6.6						20mm	97	72 - 100
7									14mm	93	60 - 90
8									10mm	79	51 - 77
9									5mm	67	42 - 65
10									7mm	49	36 - 57
11									0.425mm	33	10 - 24
12									0.075mm	18.0	2 - 9
Average:		**100.17**		**2.0**		**1079**	**205**	**93**			
Specified Ls		100.0				450	95	60	Lr =	98.19	
Spec (La):		100.19	Specimen			150mm	150mm	150mm	fr =	0.97	
Result:		**Reduce Payment**				**Pass**	**Pass**	**Pass**			

Remarks:
CONTRACTOR: DATE:
RESIDENT ENGINEER: DATE:

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APPENDIX H: STATISTICAL ANALYSIS – CRUSHED STONE

WESTERN CAPE GOVERNMENT — **DEPARTMENT OF TRANSPORT AND PUBLIC WORKS**

Acceptance Control - BASE : Granular (G3)
Max. Size: 37.5mm (Single / Upper / Lower)*

E - ASS - ACG3 - E
July 2020

Contract No. : C1000		Route/Street	Road A	Carriageway :		Lot No. :	LW085
Lane	L/S	Width	4.95	Thickness (mm) :	150	Date placed :	2020/08/04
Material	G3	Source	De Kop	From (km) : 87000	To (km) : 87500	Date sampled :	2020/08/04

LAYER PROPERTY			Comp. %	Gradation - % Passing Sieves (mm) 28.0	20.0	14.00	5.00	2.00	0.425	0.075	PI (%)	Coarse Sand Factor	Thick (mm)
Tolerance				±	±	±	±	±	±	±			
Target Value (1) / Mean Value (1)				(i) 92	(i) 79	(i) 68	(i) 43	(i) 33	(i) 20	(i) 7	4.0(1)	39.4	150
Specification Limit	La (Lower) mean		87	87	74	63	38	29	17	5			D_{90} 21mm
	La' (Upper) mean			97	84	73	48	37	23	9			D_{95} 5mm
Specification Limit	La individual			87	72	61	36	26	15	4			H_{26} 15mm
	La' individual			97	86	75	50	38	25	10	6	35	H_{max} 20
Px(SV)(m)	Py(m)	Sample No.	N	Test Value (X_n)								CSF	
87035	0.1		1	88.6	92	80	66	41	31	19	8	NP	39
87136	2.1		2	90.2	91	80	69	45	37	22	8	NP	41
87206	3.2		3	91.2	92	83	69	49	36	21	8	NP	42
87253	2.3		4	91.7	92	82	76	61	39	20	8	NP	49
87407	0.1		5	90.9	90	75	62	40	31	20	8	NP	47
87447	2.1		6	90.7	92	82	71	48	38	20	8	NP	47
			7										
			8										
			9										
			10										
Mean			$\bar{x}_n$	90.550	91.5	80.3	68.8	47.3	35.3	20.3	8.0	44.167	
Standard Deviation			S_n	1.078	0.837	2.875	4.708	7.807	3.502	1.033	0	4.021	
Outlier Value			x_o	88.6	90.0	75.0	76.0	61.0	31.0	22.0	8.0		
$\lvert x_o - \bar{x}_n \rvert$ =			C_o	1.808	1.500	5.333	7.167	13.667	4.333	1.667			
Critical Value (Std Spec Table 6704(d)(3))			C	4.6	8.7	9.4	9.4	8.0	6.2	4.0	3.5		
Outlier: Yes / No				No	No	No	No	Yes	No	No	No		
Outlier Accepted: Yes / No?								Yes					
Without Outlier	New Mean		$\bar{x}_n$	na	na	na	na	24.8	na	na	na		
	Std. Deviation		S_n	na	na	na	na	23.679	na	na	na		
ϕ	Single Limit			15									
	Double Limit				20.0	20.0	20.0	10.0	10.0	10.0	10.0		
See Std Spec (Section 8200) for k-values			k_a/k_{ad}	0.358	0.235	0.235	0.235	0.235	0.235	0.235	0.235		
			k_r/k_{rd}	0.089	-0.016	-0.016	-0.016	-0.016	-0.016	-0.016	-0.016		
$R = k_a \cdot S_n$ or $k_{ad} \cdot S_n$				0.386	0.197	0.676	1.106	5.565	0.823	0.243			
$L_A = L_S + R$				87.386	87.197	74.676	64.106	43.565	29.823	17.243	5.000		
$L_A' = L_S' - R$					86.803	73.324	61.894	32.435	28.177	16.757	5.000		
$Q = k_r \cdot S_n$ or $k_{rd} \cdot S_n$				0.096	-0.013	-0.046	-0.075	-0.379	-0.056	-0.017			
$L_E = L_S + Q$				87.096	86.987	73.954	62.925	37.621	28.944	16.983	5.000		
$L_E = L_S + Q$				87.096	86.987	73.954	62.925	37.621	28.944	16.983	5.000		
$L_E' = L_S' - Q$					87.013	74.046	63.075	38.379	29.056	17.017	5.000		
Decision average grading (IN / UN / OUT)				IN	IN	IN	IN	OUT	IN	IN	IN		
Decision individual grading (IN / UN / OUT)					IN	IN	OUT	IN	OUT	IN	IN		
Final decision (IN / UN / OUT)				IN	IN	IN	OUT	OUT	OUT	IN	IN		

Flakiness Index max 35		
Size (mm)	N +20	+14
1		
2	12.0	8.1
3		
4		
5		

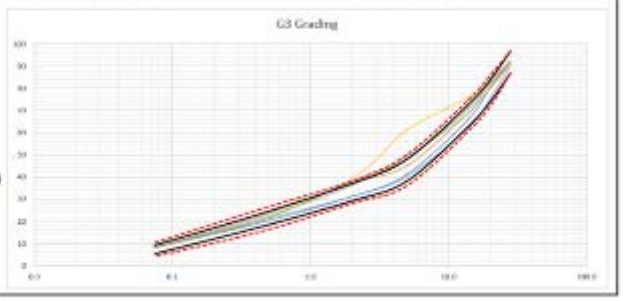
Fractured Faces or Elongation *		
Size (mm)	N	
+26.5		
+19.0		
+19.0		
+13.2		
+9.5		
+6.7		
+4.75		

Within Specification (IN) $L_S' \le \bar{x}_n \le L_S$

Uncertain (UN) $L_S \le \bar{x}_n \le L_A$ or $L_A' \le \bar{x}_n \le L_S'$

Outside (OUT) $\bar{x}_n < L_S$ or $\bar{x}_n > L_S'$

N	MDD / BRD * (kg/m³)	OMC %	Reference MDD / BRD *
1	*	*	
2	*	*	
3	*	*	
4	*	*	
5	*	*	Mean or Sequential value *
6	*	*	



Note: ***Payment Reduction Factor*** $P = 0.67 + 0.3(x_n - \bar{L}_S) / (L_A - L_S)$ or $P' = 0.67 + 0.3(LR' - xn) / (LR' - LA')$

For one sieve size, replace 0.67 and 0.3 with 0.9 and 0.1 respectively and for two or more sieve sizes, replace with 0.8 and 0.1 respectively.

Total Reduction Payment $P_t = (1 - n + \Sigma P_i)$ where

n = number of properties on which reduced payment is applicable

P_i = individual reduced payment factors relating to above properties

* Cross out whatever option is NOT applicable

Remarks:

Approved by:

Date:

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APPENDIX I: STATISTICAL ANALYSIS – ASPHALT

Consultant	TEST JOB REQUEST SITE LAB ASPHALT	Laboratory

CONTRACT No. C1000

Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

Road	From	To	Lane	Length (m	Width (m)	Thick (mm)	Area (m2)	Tons
MR531	92300	92440	LHS	140	7.14	40	1000	96
Total				140			1000	96

REQ NO:
SA007
LAYER:
Overlay
TYPE:
AC
SOURCE:
Site Plant

TEST DATA

Number of tests: 6 | Block length: 23.3 (m)

Test Position				Type of test							
No	Random	Chainage	Offset	Density	Marshall	BC	Grading	Voids	Sand Eq.	Thickness	Other
1	0.066	92302	23.3	x	x	x	x	x		x	
2	0.034	92324	3.4	x	x	x	x	x		x	
3	0.620	92338	5.2	x	x	x	x	x		x	
4	0.379	92332	2.3	x	x	x	x	x		x	
5	0.984	92348	0.2	x	x	x	x	x		x	
6	0.700	92340	3.3	x	x	x	x	x		x	
7	0.463										
8	0.035										
9	0.329										
10	0.732										
11	0.475										
12	0.973										

REMARKS

Requested by:				Received by laboratory manager:				
Date:		Time:		Date		Time:		Sign

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APPENDIX J: CHECKLISTS

Appendix J1: Concrete Side Drains Checklist

	CHECKLIST	CSD1 Rev. 0
Contract no.	Contractor:	
Description:		

CONCRETE SIDE DRAINS

Road no. _____ Location: _____ Request no.:
Position: _____ Panel no's. _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	**General**			
a	Is the start and end positions correct?			
b	Is the distance from the centre line correct?			
c	Is the drains the correct shape, width and depth?			
2	**Excavation**			
a	Is the excavation deep enough?			
b	Is the excavation clean and compacted, no loose material?			
c	Is the saw cut used at the surfacing side?			
3	**Shutters**			
a	Is the back shutter straight?			
b	Is the back shutter well supported?			
c	Is the shutter oiled?			
d	Is construction joints placed at 2,5m?			
e	Is there an expansion joint at 10m intervals?			
4	**Mesh & Concrete**			
a	**Is the correct type of mesh used?**			
b	Is cover blocks used at the bottom?			
c	Is there cover on the sides?			
d	Is the correct concrete class used?			
e	Is the surfacing projected when casting concrete?			
f	Is the concrete finish acceptable?			
g	Is the concrete vibrated with a poker?			
6	**Tolerance**			
a	**Is the concrete side drain lower than the road surface?**			
b	Are there any major cracks in the concrete?			
c	Are the front and back lines straight?			

Visual inspection done by:	(sign)	**Time**	**Date**
1	**Remarks:**		
2	**Remarks:**		
3	**Remarks:**		

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Appendix J2: Subsoil Drains Checklist

	CHECKLIST	CSS1 Rev. 0
Contract no. Description:	Contractor:	

SUBSOIL DRAIN

Road no. _____ Location: _____ Request no.:
Position: _____ Location: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	**Material**			
a	Is the correct bidum thickness used?			
b	Was bidum stored under cover (not exposed to direct sunlight)?			
c	Is the correct diameter perforated pipe used?			
d	Is the correct sand used?			
2	**Construction**			
a	**Is the trench excavated to the correct level?**			
b	**Is the trench excavated at the correct offset?**			
c	**Stone is clean and not contaminated!?**			
d	Is natural permeable material lightly compacted in 300mm layers?			
e	Is the higher end of the subsoil sealed off with a concrete cap?			
f	Cleaning eyes should be installed at 50m intervals.			
3	**Composite in-plain drainage fabric**			
a	Is the trench backfilled with saturated sand?			
b	Is upper part of trench backfilled with impermeable material?			
c	Is impermeable material compacted in 100mm layers?			
4	**Tolerance**			
a	Is the slope of the pipe correct?			
b	Polyethylene sheeting overlap 200mm, or hot-welded?			
c	Excavation width for payment as per drawing.			
d	Does the bidum overlap 300mm transversely?			
e	Does the bidum overlap on top with 300mm?			
f	Is the top of bidum stitched together at 1m intervals?			
5	**Flush test**			
a	Was a flush test done?			
Visual inspection done by:		(sign)	**Time**	**Date**
1	**Remarks:**			
2	**Remarks:**			
3	**Remarks:**			

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Appendix J3: Service Ducts Checklist

	CHECKLIST	CDS1 Rev. 0
Contract no. Description:	Contractor:	

SERVICE DUCTS

Location 1: _____ Size: _____ Request no.:
Location 2: _____ Size: _____ Date:
Location 3: _____ Size: _____
Location 4: _____ Size: _____

No.	Description	Check 1	2	3	4	Corrected Date
1	Pipe					
a	Is the pipe the right diameter?					
b	Is the pipe type correct?					
c	Is there a SABS mark on the pipe?					
d	Is the pipe cracked, or severely chipped?					
2	Excavation					
a	Is the depth and level of the excavation correct?					
b	Is the excavation wide enough to compact backfill?					
c	Is the bedding material correct?					
d	Is temporary shoring adequate?					
e	Is underground water accommodated?					
3	Bedding					
a	Is there any rock or unsuitable material to be replaced?					
b	Is the grading of the bedding material correct?					
c	Is the bedding sand/gravel thick enough? min 75mm.					
d	Is the bedding stable and compacted?					
e	Is the bedding level?					
4	Placing / instalment					
a	Is the culvert placed in a straight line?					
b	Are anchor installed at bends for pressure pipes?					
c	Sewer pipes to be placed at minimum of 1% slope					
5	Joints					
a	Does all joints fit tightly?					
b	Is gap between multi barrel portal culvert fill with concrete?					
c	Are joints wrapped in bitumen impregnated burlap?					
6	Backfill					
a	Is the backfilling blanket material approved?					
b	Is the blanket backfilled 300mm above the pipe?					
c	Is the backfilling at optimum moisture?					
d	Is soilcrete specified and used for backfilling?					
e	Is backfilling done in 150mm layers, both side simultaneously?					
f	Is backfill of layer work benched back into the existing layer?					
7	Concrete casing					
a	Is the poker vibrator used to fill all cavities around pipe?					
8	Testing					
a	Did the laboratory come to take densities?					
Visual inspection done by:	(sign)	**Time**				**Date**
1	**Remarks:**					
2	**Remarks:**					
3	**Remarks:**					

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Appendix J4: Kerb and Channel Checklist

	CHECKLIST	CKC1 Rev. 0
Contract no. Description:		Contractor:

KERB & CHANNEL

Road no. _____ Location: _____ Request no.:
Location: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	**General**			
a	**Is the correct type of kerbs used?**			
b	Is the kerbs start and end positions correct?			
c	Is the distance from the centre line correct?			
d	Are 300mm kerb units used at sharp curves?			
e	Is the down chute or transition in the correct place?			
2	**Construction**			
a	Is the bedding material correct?			
b	Is the thickness of the bedding correct?			
c	Is kerb face damaged?			
d	Are the surfacing saw cut?			
e	Is the channel excavation deep enough?			
f	Is the line of the channel at the kerb face correct?			
g	Are haunching placed at the back of kerbs?			
h	Are construction joints spacing correct?			
i	Are all concrete spills removed and painted with emulsion?			
3	**Tolerance**			
a	**Is the kerbs in a straight horizontal line?**			
b	Is the height of the kerb correct and in a vertical straight line?			
c	**Are bends and curves gradual and smooth?**			
d	Is the spacing between the kerbs correct?			
e	Does the water flow in the channel?			

Visual inspection done by:	(sign)	Time	Date
1	**Remarks:**		
2	**Remarks:**		
3	**Remarks:**		

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Appendix J5: Culvert Pipes Checklist

	CHECKLIST	CCP1 Rev. 0
Contract no. Description:		Contractor:

CULVERT PIPES

Location 1: _____ Size: _____ Request no.:
Location 2: _____ Size: _____ Date:
Location 3: _____ Size: _____
Location 4: _____ Size: _____

No.	Description	Check 1	2	3	4	Corrected Date
1	Storage corrugated metal culverts					
a	Is nestable culverts stored to avoid moisture on contact faces?					
2	Location					
a	Is the pipe placed at the correct location? Low point?					
3	Pipe					
a	Is the pipe the right diameter?					
b	Is the pipe thickness correct?					
c	Is the pipe type correct?					
d	Is there a SABS mark on the pipe?					
e	Is the pipe cracked, or severely chipped?					
4	Excavation					
a	Is the depth and level of the excavation correct?					
b	Is the excavation wide enough to compact backfill?					
c	Is the bedding material correct?					
d	Is the bedding stable and compacted?					
e	Is the bedding level?					
f	Is temporary shoring adequate?					
g	Is underground water accommodated?					
5	Bedding					
a	Is there any rock or unsuitable material to be replaced?					
b	Is the grading of the bedding material correct?					
c	Is the bedding sand/gravel thick enough? min 75 mm					
d	Precast portal slabs: Is the bedding compacted & trimmed?					
6	Placing / instalment					
a	Is the culvert placed in a straight line?					
b	Is the precast floor for portal culvert properly bedded?					
c	Is mortar placed on floor slabs of portal culverts?					
d	Is the whole in centre of pipe closed?					
e	Are anchor bolts installed at the end of metal culverts?					
f	Are layer of concrete used at steep metal culverts as per dwg?					
g	Half width instalment, is the traffic end properly supported?					
7	Joints					
a	Does all joints fit tightly?					
b	Is gap between multi barrel portal culvert fill with concrete?					
c	Are joints wrapped in bitumen impregnated burlap?					
d	Is joints of portal culverts treated with 60% bitumen emulsion?					
e	Is filter fabric specified between outer joints of portal culverts?					
8	Backfill					
a	Is the backfilling blanket material approved?					
b	Is the blanket backfilled 300mm above the pipe?					
c	Is the backfilling at optimum moisture?					
d	Is soilcrete specified and used for backfilling?					
e	Is backfilling done in 150mm layers, both side simultaneously?					
f	Is backfill of layer work benched back into the existing layer?					
9	Concrete casing					
a	Is the poker vibrator used to fill all cavities around pipe?					
10	Testing					
a	Did the laboratory come to take densities?					
Visual inspection done by:	(sign)	**Time**				**Date**
1	**Remarks:**					
2	**Remarks:**					
3	**Remarks:**					

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Appendix J6:Pre-Concrete Checklist

	CHECKLIST	CCC1 Rev. 0

Contract no. Contractor:
Description:

PRE CONCRETE

Location 1: _____ Concrete class: _____ Request no.:
Location 2: _____ Method of placing: _____ Date:
Location 3: _____ Method of curing: _____
Location 4: _____ Finishing requirements: _____ Date concrete cast:
Required air temperature > 2 C and < 32 C

No.	Description	Check		Corrected	
		Forman	Engineer	Date	Time
1	**Drawings**				
a	Is the latest drawing revision used?				
2	**Survey**				
a	Is the position and level of structure correct? Survey check.				
3	**Formwork**				
a	Is the position of the structure correct, vertical and square?				
b	Is the dimensions correct (thickness/height of structure)?				
c	Is there any openings where concrete can leak out?				
d	Is the box-outs properly done?				
e	Is the corner fillet correct and secure?				
f	Is formwork properly braced, so that it will not "kick"?				
g	Is formwork cleaned and oiled?				
h	Is bottom clean?				
4	**Reinforcing**				
a	Is reinforcing the correct diameter?				
b	Are all the reinforcement bars there?				
c	Is the spacing and position of the reinforcing correct?				
d	Is the reinforcement the correct shape?				
e	Is the correct cover blocks used?				
f	Is the cover between bars and the side of formwork correct?				
g	Is the cover between bars and the side of formwork correct?				
h	Is the bottom and top cover correct?				
5	**HD Bolts**				
a	Is the position correct?				
b	Is the projection correct?				
c	Is the right size and type bolts used?				
d	Is the correct number of bolts used?				
e	Is the fastening / template correct?				
f	Is the pocket / sleeves in the right diameter and position?				
6	**Embedded Items. Specify item:**				
a	Is the position correct?				
b	Is the correct item used?				
7	**Movement joints**				
a	Is the correct type of joint installed?				
b	Is the position correct?				
c	Is the joint preparation correct?				
8	**Access and safety**				
a	Is the access acceptable?				
b	Is the area safe?				

Inspection comments:

Site Agent Name: _____ Sign: _____ Date: _____
R. E. Name: _____ Sign: _____ Date: _____

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Appendix J7: Concrete Checklist

	CHECKLIST	CCC2 Rev. 0
Contract no. Description:	Contractor:	

CONCRETE

Structure 1: _____ Location: _____ Request no.:
Structure 2: _____ Location: _____ Date:
Structure 3: _____ Location: _____
Structure 4: _____ Location: _____

No.	Description	Check				Corrected	
		1	2	3	4	Time	Date
1	**Concrete**						
a	Are there enough moulds for concrete cube tests?						
b	Is the correct class of concrete used?						
c	Is the slump of the concrete correct?						
d	Does the concrete segregate when using chutes?						
e	Is the concrete workable?						
f	Is the concrete vibrated with pokers?						
g	Is the concrete over vibrated; segregation and bleeding?						
h	Is the reinforcement clean, no dry concrete sticking to it?						
i	Is absorbing surfaces damp?						
j	Is there standing water on the surface?						
k	Is the inside surface clean?						
l	Is the bucket/mixer cleaned, hardened concrete removed?						
m	Is the ambient and concrete temperature correct?						
2	**Joints**						
a	Is construction joint clean, hard and with irregular surface?						
b	Is construction joint saturated with water and dried/damp?						
3	**Finishing**						
a	Is the correct equipment used for finishing?						
4	**Curing**						
a	Are concrete being cured?						
b	Is curing compound used?						
Visual inspection done by:		(sign)				**Time**	**Date**
1	**Remarks:**						
2	**Remarks:**						
3	**Remarks:**						
	APPROVED BY:	**Time:**				**Date:**	

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Appendix J8: Post-Concrete Checklist

	CHECKLIST	CCC3 Rev. 0
Contract no.	Contractor:	
Description:		

POST CONCRETE

Location 1: _____ Request no.:
Location 2: _____ Date:
Location 3: _____
Location 4: _____

No.	Description	Check		Corrected	
		Forman	Engineer	Date	Time
1	**Surface status**				
a	Are there any major defects?				
b	Are the remedial work acceptable?				
c	Are the curing acceptable?				
2	**Overall dimensions and levels**				
a	Is the horizontal levels correct?				
b	Is the vertical levels correct?				
c	Is the levels correct?				
3	**Overall position**				
a	Survey check required?				
4	**Built-in items**				
a	Is the position correct?				
b	Is the projection correct?				
c	Is the levels correct?				
d	Is all the conditions sound and acceptable?				
5	**Joint sealing**				
a	Is the joints complete?				
b	Are there and defects?				
6	**Concrete cover**				
a	Is the concrete cover to reinforcing acceptable?				

Inspection comments:

Site Agent Name: _____ Sign: _____ Date: _____

R. E. Name: _____ Sign: _____ Date: _____

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Appendix J9: Layer Work Checklist

	CHECKLIST	CLW1 Rev. 0
Contract no. Description:	Contractor:	

LAYER WORK

Layer: _____ Request no.:
Location: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	Pre-shape			
a	Is there enough material?			
b	Is the correct material used?			
c	Is there organic material or clay?			
2	Mixing and moisture			
a	Is the layer homogeneously mixed?			
b	Is the layer mixed to the correct depth?			
c	Is oversized material removed?			
d	Is the moisture content correct?			
3	Compaction			
a	Is the layer compacted right to the edge?			
b	Is the layer compacted wide enough?			
c	Are there any bridging?			
d	Ensure there are not biscuit layers.			
5	Final cut			
a	Are levels cut the correct level?			
b	Are hollow spots filled in with fine wet material?			
6	Testing			
a	Did the laboratory come to take samples?			
b	Visual test with truck to check pumping?			
Visual inspection done by:		(sign)	**Time**	**Date**
1	**Remarks:**			
2	**Remarks:**			
3	**Remarks:**			

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Appendix J10: Stabilising Checklist

	CHECKLIST	CLW1 Rev. 0
Contract no. Description:	Contractor:	

STABILISING

Layer: _____ Request no.:
Location: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	Pre-shape			
a	Is there enough material?			
b	Windrow too big? Reclaimer not mixing to bottom.			
c	Is the correct material used?			
d	Is there organic material or clay?			
2	Stabilization			
a	Is the stabilisation evenly spread?			
b	Is the stabilisation agent old or wet?			
3	Mixing and moisture			
a	Is the layer homogeneously mixed?			
b	Is the layer mixed to the correct depth?			
c	Is oversized material removed?			
d	Is the moisture content correct?			
e	Is the mixing time within specification?			
4	Compaction			
a	Is the layer compacted right to the edge?			
b	Is the layer compacted wide enough?			
c	Are there any bridging?			
d	Ensure there are not biscuit layers.			
5	Final cut			
a	Are levels cut the correct level?			
b	Are hollow spots filled in with fine wet material?			
6	Testing			
a	Did the laboratory come to take samples?			
b	Visual test with truck to check pumping?			
7	Curing			
a	Are layer being cured?			
Visual inspection done by:		(sign)	**Time**	**Date**
1	**Remarks:**			
2	**Remarks:**			
3	**Remarks:**			

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Appendix J11: Crushed Stone Checklist

	CHECKLIST	CLW1 Rev. 0
Contract no.	Contractor:	
Description:		

CRUSHED STONE

Layer: _____ Request no.:
Location: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	General			
a	Ensure layer underneath is approved and dry.			
b	Crushed stone not contaminated with the shoulder material.			
c	Look for coarse sections, add fine material before slushing.			
d	Crushed stone not to be over compacted when slushed.			
e	Stop when no more bubbles is visible in front of steel roller.			
f	Stop when too much fines is visible in the windrow			
g	Cutting blade should be straight, replace cutting edges often.			
h	The layer need to be protected from public driving.			
	Note: The layer may be rejected after it was approved when rain or vehicle damage is visible.			
Visual inspection done by:		(sign)	**Time**	**Date**
1	**Remarks:**			
2	**Remarks:**			
3	**Remarks:**			

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Appendix J12: Prime Checklist

	CHECKLIST	CPR2 Rev. 0
Contract no. Description:	Contractor:	

PRIME

Road no. _____ Request no.:
Location: _____ Date:

No.	Description Source: SAPEM 12 page 95	Check
1	Base preparation	
a	Completed	
b	According to specification	
c	Cured	
d	Withing time limit for stabilized base	
e	Granular base < 50% of OMC	
2	Spray preparation	
a	Cleaned	
b	Dampened	
c	String lines	
d	Joint paper	
e	No wet prime	
3	Materials: Sampling, testing and specifications	
a	Binder	
b	Correct type	
c	Stored temperature	
d	Spray temperature	
e	Properties	
f	Aggregate	
g	Blinding for excess removal	
h	Blinding for traffic accommodation	
i	Treatment of wet areas before seal	
j	Aggregate properties	
4	"No go" environmental conditions	
a	Misty or wet conditions	
b	Rain threatening	
c	Strong wind blowing that would cause an uneven application	
d	Temperature of the road surface dropped below 20 °C before priming	
e	(10 °C in case of MC-10 or emulsion)	
f	After sunset	
5	Equipment condition checks	
a	Binder distributor	
b	Water sprinkler	
c	Rotary broom	
d	Other equipment	
6	Application rate	
a	Trial confirmation	
b	Effective width	
7	After care	
a	Traffic off	
b	Dry before sealing	
c	Blinded for traffic accommodation	

Visual inspection done by: (sign)		Time	Date
1	**Remarks:**		
2	**Remarks:**		
3	**Remarks:**		

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Appendix J13: Pre-Seal Checklist

	CHECKLIST	CSE1 Rev. 0
Contract no. Description:	Contractor:	

PRE-SEAL

Seal type: _____ Request no.:
Binder type: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	Prime			
a	Top 50mm of base 50% below optimum moisture?			
b	Is the surface broomed, clean, without dust?			
c	Base damp before spray to break surface tension?			
2	Design			
a	Are the ball penetration and sand patch test done?			
b	Is the grading and ALD of the aggregate tested and in spec?			
c	What is the design application rate?			
3	Precoating			
a	Must the aggregate be precoated?			
b	Is the type of precoating approved?			
c	What is the application rate of the precoating?			
d	Is the aggregate too dusty/not washed?			
4	Surface clean			
a	Is the surface broomed, clean, without dust?			
b	Is the road studs of the existing road removed?			
5	Chipping			
a	Was a dry run done to check the application rate?			
b	What is approved application rate of aggregate?			
6	Tack coat			
a	Is the road and ambient temperature high enough?			
b	Is the centreline/outside edge clean from dust, or washed?			
c	Check expiry date of spray certificate.			
d	Is the bucket test done?			
e	Is the temperature of the bitumen correct?			
f	Did the binder burn?			
g	Does the driver know what the application rate is?			
h	What is the softening point of the product before spraying?			
i	What is the viscosity of the product before spraying?			
j	Is the truck level when taking dips?			
k	Is the joint correct? Overlap or end nozzle turned			
l	Is the wind causing the nozzles not to overlap?			
7	Chipping			
a	What is the actual application rate of aggregate?			
b	Is the gap between the aggregate too big?			
c	Any double joints visible?			
d	What is the stone loss?			
8	Compaction			
a	Is the water on steel wheel roller working?			
b	Does the PTR roll at least 3 times?			
c	Is the aggregate rolled while the road is still hot?			
9	Testing			
a	Did the laboratory come to take samples?			
Visual inspection done by:		(sign)	**Time**	**Date**
1	**Remarks:**			
2	**Remarks:**			
3	**Remarks:**			

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Appendix J14: Slurry Checklist

	CHECKLIST	CSL1 Rev. 0
Contract i Descriptic	Contractor:	

SLURRY

Location 1: _____ Request no.:
Location 2: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	**General**			
a	Confirm the quantity of emulsion per dry c/dust to be used.			
b	Turn emulsion drums before use, emulsion settles at bottom.			
c	Check moisture content of crusher dust.			
2	**Volume batching**			
a	Calculate volume of hopper/truck			
b	Calculate bulking factor of crusher dust.			
c	Adjust emulsion or reference volume for truck/hopper for bulking			
d	Adjust cement for bulking factor.			
3	**Mass batching**			
a	Adjust weight for moisture correction.			
b	Emulsion / cement rate remains constant.			
4	**Taking samples**			
a	Take sample with a bucket, as it comes out of the truck,			
b	Do not take a sample from the road.			
5	**Application**			
a	Pre-wet the surface to cool down and break surface tension.			
b	Check colour and consistency of the slurry			
c	Squeegee must be hard and long for fill gaps.			
d	Use a guide rope at edges of the road.			
e	Monitor the thickness of the slurry.			
5	**Notes**			
a	Use stable grade emulsion, to prevent early breaking			
b	Cool the road or drum to prevent early breaking			
c	Avoid working in the middle of the day to prevent bleeding.			

Visual inspection done by: (sign)	**Time**	**Date**
1 **Remarks:**		
2 **Remarks:**		
3 **Remarks:**		

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Appendix J15: Asphalt Checklist

	CHECKLIST	CAS1 Rev. 0
Contract no. Description:	Contractor:	

ASPHALT

Asphalt type: _____ Request no.:
Binder type: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	Tack coat			
a	Is the surface clean, without dust?			
b	Is the correct amount of tack coat used?			
c	Are puddles swept out and left to dry?			
2	Asphalt			
a	Is the correct asphalt mix used?			
b	Is the temperature of the asphalt correct?			
c	Did the binder burn?			
d	Is the thickness of the asphalt correct?			
e	Is the joint correct?			
f	Is the asphalt segregating?			
g'	Is the paver paving uphill?			
3	Paving			
a	Are the paver or rollers leaking oil?			
b	Is the levelling beam working and used?			
c	Is the screed hot enough?			
d	Is the tamping bars working?			
e	Is cold asphalt lumps removed?			
f	Is coarse sections binded with fine material?			
4	Compaction			
a	Is the tires of the PTR pumped?			
b	Is the water on steel wheel roller working?			
c	Is the rollers heavy enough?			
d	Is the asphalt still hot while it is being compacted?			
4	Testing			
a	Did the laboratory come to take samples?			
Visual inspection done by:		(sign)	**Time**	**Date**
1	**Remarks:**			
2	**Remarks:**			
3	**Remarks:**			

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Appendix J16: Road Markings Checklist

	CHECKLIST	CRM1 Rev. 0
Contract no. Description:	Contractor:	

ROAD MARKINGS

Road no. _____ Request no.:
Location: _____ Date:

No.	Description	Check	Corrected	
			Time	Date
1	**Location**			
a	Is the barrier lines start and end positions correct?			
b	Is the width of the broken lines correct?			
c	Is the width of the barrier lines correct?			
d	Is the width of the yellow lines correct?			
e	Is the spacing between broken lines correct?			
2	**Traffic accommodation**			
a	Is there ample warning when painting lines?			
c	Are cones placed at regular intervals after road is painted?			
d	Are flagman far enough ahead and behind spray vehicle?			
3	**Paint**			
a	Is the correct type of paint used?			
b	Is the application rate correct? Thickness of the paint?			
c	Is the edges of the lines feathering?			
d	Is the correct amount of beads used?			
e	Is the beads spread over the full width of the paint?			
f	Is the line spacing and curves acceptable?			
Visual inspection done by:		(sign)	**Time**	**Date**
1	**Remarks:**			
2	**Remarks:**			
3	**Remarks:**			

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APPENDIX K: WORKSHEETS

Appendix K1: Concrete Worksheet

	CONCRETE	WCC1 Rev. 0
Conctract no.	WORKSHEET	Contractor:

Bridge no. _____ Structure _____ Slump _____ mm Concrete class _____ Date: _____

CASTING CONCRETE

No.	Truck no.	Time			Invoice no.	Vol. m3	Temperature		Water added	Slump		Lab cubes	Cast Position
		Dispatch	Arrive	Discharge			Conc	Air		Plant	Site		
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
Total													

PROBLEMS AND DELAYS

_____

_____

_____

MACHINES AND LABOUR			SIGNED	
Pokers: _____	Concrete pump: _____	Labour: _____	Contractor: _____	
Crane & Bucket: _____	Foreman: _____	Skilled: _____	Consultant: _____	

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Appendix K2: Culvert Worksheet

	CULVERTS	WCV1 Rev. 0
Conctract no.	WORK SHEET	Contractor:

FOREMAN						Date:
Road no.	Km	Size	Pos	Description	Qty	Remarks
FOREMAN						

WEATHER / COMMENTS:

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Appendix K3: Bitumen Stabilised Layers Worksheet

	BITUMEN STABILISED LAYER	WPL3 Rev. 0
Conctract no.	WORKSHEET	Contractor:

ROAD NO			STABILIZTION					BINDER TYPE				DATE		
MOD			DEPTH		AGENT			CEMENT BAG SPACING				ROWS		
FROM km	TO km	LANE	LENGTH m	WIDTH m	VOLUME m^3	EMULSION / BINDER QAUNTITY litres						MIX - COMPACT		
						dip before	dip after	used	flow meter	% dilute	% bit	start	finish	hours
TOTAL VOLUME m^3						TOTAL BINDER				TOTAL CEMENT tons				
TOTAL ACC VOLUME m^3					TOTAL ACC BINDER LITRES					TOTAL ACC CEMENT tons				

Remarks / Breakdowns / Delays & Weather

	Permanent		Local	
Personel	Female	Male	Female	Male
Foreman				
Operators				
Labour				
Flagmen				

Plant			
Reclaimer		Grader	
Water truck		PTR	
Bitumen tank		Broom	
Steel roller		Other	

CONTRACTOR

RE / CLERK OF WORKS

candidate® academy
the road to registration – tower above the rest

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Appendix K4: Stabilisation (Bulk) Worksheet

	STABILISATION (BULK)	WPL1 Rev. 0
Conctract no.	WORKSHEET	Contractor:

ROAD NO.		LENGTH		MATERIAL			DATE		
LANE		MOD		DEPTH (mm)			% CEMENT		
LAYER		CLASS		WIDTH (m)			AGENT		
	TRUCK 1			TRUCK 2			TRUCK 3		
KM									
MIX-COMPACK	START	FINISH	TOTAL	START	FINISH	TOTAL	START	FINISH	TOTAL
TIME									
	USED	REQ	DIFF	USED	REQ	DIFF	USED	REQ	DIFF
CEMENT tons									
TONS CALC									
Applied %									
LANE 1	LHS	Centre	RHS	LHS	Centre	RHS	LHS	Centre	RHS
Canvas 1									
Canvas 2									
Canvas 3									
Canvas 4									
Canvas 5									
LANE 2	LHS	Centre	RHS	LHS	Centre	RHS	LHS	Centre	RHS
Canvas 6									
Canvas 7									
Canvas 8									
Canvas 9									
Canvas 10									
Average									
Tons required: length x width x depth x mod x %cement				Canvas: 1m x 1m x depth x mod x % cement =					
REMARKS									
CONTRACTOR				RESIDENT ENGINEER / CLERK OF WORKS					

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Appendix K5: Sealwork Worksheet

	SEALWORK	WSW1 Rev. 0
Conctract no.	WORKSHEET	Contractor:

ROAD NO		BINDER TYPE			STONE SIZE		SPRAY TYPE				DATE	
STONE APPLICATION RATE				PRECOAT AGENT			RATE		l/m2	WEATHER		

FROM km	TO km	LANE	LENGTH m	WIDTH m	AREA m²	TIME	TEMPERATURE °C air	road	binder	BINDER QAUNTITY litres before	after	used	RATE l/m² spray	spec	VISCOSITY Time	cP	SAMPLE Ref no.

TOTAL AREA m²		TOTAL BINDER LITRES		TOTAL STONE m³

PROBLEMS / DELAYS & WEATHER

Plant	
Distrutor	
Chip spreader	
Tippers	
PTR	
Broom	

CONTRACTOR

RE / CLERK OF WORKS

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Appendix K6: Slurry Worksheet

	SLURRY	WSL1 Rev. 0
Conctract no.	WORKSHEET	Contractor:

ROAD NO.		SLURRY TYPE				APPLICATION (l/m3)			SOURCE			DATE	
TIME	KM	KM	POS	LENGTH	WIDTH	AREA	BEFORE	AFTER	LITERS	VOLUME	l/m3	THICKNESS	FLOW
TOTAL													

	Permanent Labour		Local Labour	
Personel	Female	Male	Female	Male
Site agent				
Foreman				
Operators				
Labour				
Flagmen				

Plant	
Batching plant/mixer	
Slurry truck	
Water tank	
PTR	
TLB	
Compressor	

PROBLEMS / DELAYS & WEATHER

CONTRACTOR

RE / CLERK OF WORKS

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Appendix K7: Paving Asphalt Worksheet

	PAVING ASPHALT	WAS1 Rev. 0
Conctract no.	WORKSHEET	Contractor:

ROAD NO		LAYER		ASPHALT GRADE					BINDER TYPE				DATE		
LOAD No	TONNES	ACC TONNES	FROM km	TO km	LANE	LENGTH m	WIDTH m	AREA m²	ACC AREA m²	PLANT TEMP °C	PAVE TEMP °C	TIME ARRIVE	TIME PAVED	THICK mm	SAMPLE
TOTAL TONNES					TOTAL AREA						TOTAL TACK USED				

Problems and delays:

Thickness (mm) = tons / area / bulk desity (tons/m3) x 1000

Plant

Paver	
Tippers	
PTR	
Three wheel roller	
Tandem roller	

CONTRACTOR

RE / CLERK OF WORKS

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APPENDIX L: EXAMPLE OF LEVEL AND THICKNESS CONTROL

LEVEL CONTROL

Layer: Base | Section: LHS | BC - Lot of the Day | Date: 21/8/2020

SV	Design Level	Asbuild Level	Diff.	Design Level	Asbuild Level	Diff	Design Level	Asbuild Level	Diff	Remarks
	CL	CL		2.000	2.000		4.000	4.000		
86560	4.003	4.007	0.004	3.953	3.956	0.003	3.903	3.891	-0.012	
86580	4.290	4.286	-0.004	4.240	4.239	-0.001	4.190	4.178	-0.012	
86600	4.484	4.475	-0.009	4.434	4.432	-0.002	4.384	4.372	-0.012	
86620	4.596	4.595	-0.001	4.546	4.540	-0.006	4.496	4.479	-0.017	
86640	4.700	4.698	-0.002	4.650	4.649	-0.001	4.600	4.607	0.007	
86660	4.822	4.810	-0.012	4.772	4.771	-0.001	4.722	4.710	-0.012	
86680	4.992	4.981	-0.011	4.942	4.939	-0.003	4.892	4.881	-0.011	
86700	5.193	5.183	-0.010	5.143	5.141	-0.002	5.093	5.090	-0.003	
86720	5.342	5.344	0.002	5.292	5.286	-0.006	5.242	5.234	-0.008	
86740	5.385	5.384	-0.001	5.335	5.343	0.008	5.285	5.288	0.003	
86760	5.374	5.366	-0.008	5.324	5.328	0.004	5.274	5.283	0.009	
86780	5.267	5.275	0.008	5.217	5.232	0.015	5.167	5.182	0.015	
86800	5.000	5.010	0.010	4.950	4.962	0.012	4.900	4.914	0.014	
86820	4.669	4.681	0.012	4.619	4.621	0.002	4.569	4.557	-0.012	
86840	4.337	4.345	0.008	4.287	4.291	0.004	4.237	4.239	0.002	
86860	4.010	4.020	0.010	3.960	3.966	0.006	3.910	3.912	0.002	
86880	3.759	3.769	0.010	3.709	3.711	0.002	3.659	3.662	0.003	
86900	3.609	3.620	0.011	3.559	3.573	0.014	3.509	3.529	0.020	
86920	3.560	3.573	0.013	3.510	3.522	0.012	3.460	3.474	0.014	
86940	3.613	3.618	0.005	3.563	3.576	0.013	3.513	3.527	0.014	
86960	3.766	3.780	0.014	3.716	3.729	0.013	3.666	3.677	0.011	
86980	4.015	4.034	0.019	3.965	3.977	0.012	3.915	3.924	0.009	
87000	4.290	4.303	0.013	4.240	4.244	0.004	4.190	4.188	-0.002	
Count		Hmax	23		Hmax	23		Hmax	23	
Rejected Count		0	1		0	0		0	1	
		0	0		0	0		0	1	
R/Count			1			0			2	
% Rejected			4			0			9	
% Accepted			96			100			91	
				H90			Hmax			
			CL	2	4	Total	0			
	% Out of Tolerance		4	0	9					
	% In Tolerance		96	100	91	Ave%	95.7			
							Layer			
							Accept			

Levels

Acceptance Limits

H90/H max

L'a/La 15 -15

Submitted by:

Site Agent

Date:

Note:

Clauses 3405,8205,8305

Approved by:

Resident Engineer

Date:

Approved ☐

Rejected ☐

	H90	HMAX
SSG	25	33
SUBBASE	20	25
BASE	15	20

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LAYER THICKNESS

Layer: Base | Section: LHS | BC Thickness of Lot | Date: 21/8/2020

SV	Asbuild Level SUBBASE	Asbuild Level BASE	Diff.	Asbuild Level SUBBASE	Asbuild Level BASE	Diff	Asbuild Level SUBBASE	Asbuild Level BASE	Diff	Remarks
	CL	CL		2	2		4	4		
86560	3.855	4.007	0.152	3.807	3.956	0.149	3.763	3.891	0.128	
86580	4.145	4.286	0.141	4.091	4.239	0.148	4.040	4.178	0.138	
86600	4.332	4.475	0.143	4.286	4.432	0.146	4.239	4.372	0.133	
86620	4.445	4.595	0.150	4.399	4.540	0.141	4.341	4.479	0.138	
86640	4.549	4.698	0.149	4.499	4.649	0.150	4.452	4.607	0.155	
86660	4.661	4.810	0.149	4.621	4.771	0.150	4.567	4.710	0.143	
86680	4.842	4.981	0.139	4.792	4.939	0.147	4.745	4.881	0.136	
86700	5.040	5.183	0.143	4.993	5.141	0.148	4.943	5.090	0.147	
86720	5.183	5.344	0.161	5.141	5.286	0.145	5.083	5.234	0.151	
86740	5.237	5.384	0.147	5.194	5.343	0.149	5.138	5.288	0.150	
86760	5.224	5.366	0.142	5.173	5.328	0.155	5.125	5.283	0.158	
86780	5.115	5.275	0.160	5.068	5.232	0.164	5.012	5.182	0.170	
86800	4.849	5.010	0.161	4.803	4.962	0.159	4.754	4.914	0.160	
86820	4.521	4.681	0.160	4.473	4.621	0.148	4.415	4.557	0.142	
86840	4.187	4.345	0.158	4.137	4.291	0.154	4.082	4.239	0.157	
86860	3.834	4.020	0.166	3.816	3.966	0.150	3.749	3.912	0.163	
86880	3.608	3.769	0.161	3.559	3.711	0.152	3.511	3.662	0.151	
86900	3.460	3.620	0.160	3.416	3.573	0.157	3.353	3.529	0.176	
86920	3.409	3.573	0.164	3.369	3.522	0.153	3.304	3.474	0.170	
86940	3.463	3.618	0.155	3.418	3.576	0.158	3.367	3.527	0.160	
86960	3.606	3.780	0.174	3.566	3.729	0.163	3.505	3.677	0.172	
86980	3.866	4.034	0.168	3.811	3.977	0.166	3.755	3.924	0.169	
87000	4.145	4.303	0.158	4.090	4.244	0.154	4.030	4.188	0.158	
Count		Hmax	23		Hmax	23		Hmax	23	
Rejected Count		0	1		0	0		0	2	
		0	0		0	0		0	1	
R/Count			1			0			3	
% Rejected			4			0			13	
% Accepted			96			100			87	
			D90				Dmax			
			CL	2	4	Total	0			
	% Out of Tolerance		4	0	13					
	% In Tolerance		96	100	87	Ave%	94.2			
							Layer			
	AVG		0.155	0.152	0.153		Accept			
D ave=5mm		0.154								

Levels
Acceptance Limits
D90/Dmax
L'a/La 21 :21

Submitted by:
Site Agent
Date:

Approved by:
Resident Engineer
Date:

Approved ☐
Rejected ☐

Note:
Clauses 3405,8205,8305

	D90	Dmax
SSG	30mm	40mm
SUBBASE	21mm	27mm
BASE	21mm	27mm

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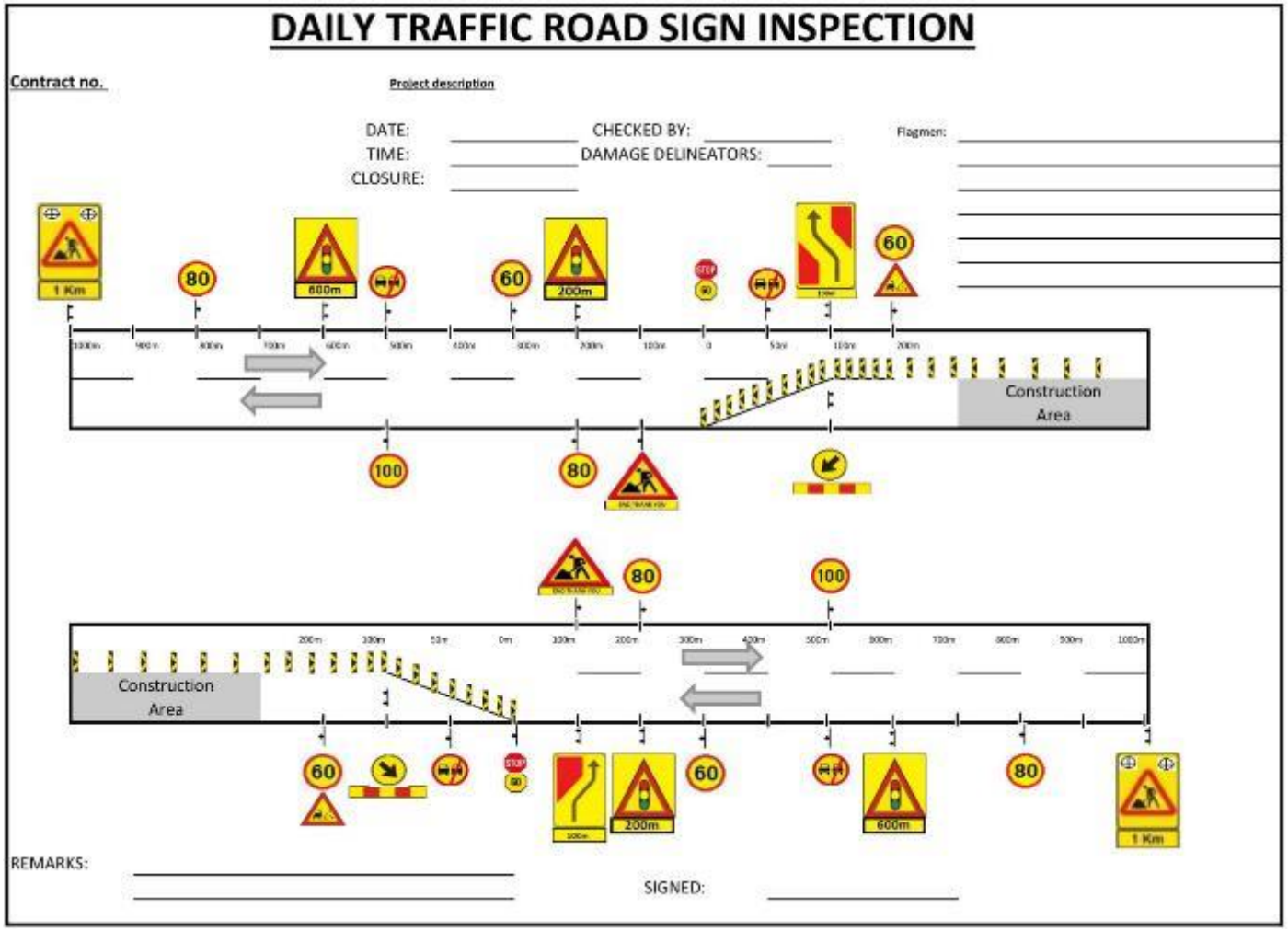
APPENDIX M: TRAFFIC INSPECTION



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APPENDIX N: EXAMPLE OF SITE INSTRUCTION

Consultant	SITE INSTRUCTION	No. 3 Date: 08-Apr-2016
Contract No: C1000	**Contractor**: Contractor A	
Contract Description:	Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)	
Subject:	Gravel shoulder	

List of gravel shoulders to be constructed on R503/1:

km 24 - km 24.2 LHS 200m
km 24.45 - km 24.55 RHS 100m
km 24.83 - km 24.93 RHS 100m
km 25.2 - km 25.3 LHS 100m
km 25.2 - km 25.3 RHS 100m
km 28.27 - km 28.4 LHS 130m
km 36.62 - km 36.7 LHS 80m
km 36.62 - km 36.7 RHS 80m
km 52.3 - km 52.37 LHS 70m
km 58 - km 58.1 LHS 100m
km 63.35 - km 63.7 LHS 350m
km 64.5 - km 65.5 LHS 1000m
km 64.5 - km 65.5 RHS 1000m
Total length 3410m

Resident Engineer: Mr. Right	**Date:**
Payment Item No.	39/34.01 g) i)
Comments:	
Received by:	**Date:**

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APPENDIX O: REQUEST FOR INFORMATION

	Request For Information/ Site Engineer Query/ Technical Query Notice	Doc No.	F07
		Rev. No.	11
		Rev. Date	25/01/2016

Project:	**D1944 RUST DE WINTER**	**Contract No.**	**TQ1**
To:	Shake Chambati	Date:	19-May-17
Attention :	Shake Chambati	Fax/Email:	0
From:	Byron Schooling	RFI No./Seq/TQN No.	1
Subject:	Horizontal Alignment	Submitted by:	Shimmy Mere
		Date Required:	22-May-17

PRIORITY	X	High (1-2 Days)		Medium (3-4 days)		Low (5-7 Days)

Nature of Query:

There seem to be a problem with the Horizontal Alignment as it does not tie in at the beginning and the end of the construction points. Can you please revise and provide more info regarding this matter thanks. Please find attached Coordinates showing cl of the existing road and yellow lines.

Signed By:	Byron Schooling	Title:	surveyor	Date:	19-May-17
Received By:	Shake Chambati	Title:		Date:	

Reply By: Architech / Consultant Engineer

Name:	Signature:	Date:
Reply Received Contractor		
Name:	Signature:	Date:

Payment:

Bill item	Day Works	New Rates

The response/approval of this SEQ/ RFI will be deemed to be a Site Instruction to the Contractor.

The Contractor's suggestion are not to be regarded as designs or specifications. The design remains with the Clients' Professional Team.

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APPENDIX P: TECHNICAL QUERY

	Technical Query	CONTRACT N° 171/OBR/RE/DEN/2002 The Rehabilitation of Road EN1 between Muxungue and Inchope in the Sofala Province of Mozambique. Ref No: T Q / 0 0 10 Seq No

From: Jason Nash Position: Resident Engineer Date: 04-May-05

To: Nick Kong Position: Pavement Engineer

Project: EN242 Litunde to Cabo Del Gado Border (H039503)	Location: Niassa Province, Northern Mozambique

Item	Contractor / Resident Engineer's Query	Item	Designer's Response
1	**Is the loading of a Bell B20D 18000 litre water bowser within the tolorances of Road EN242?** **Specification of truck -** already supplied **Specification of road:** Base - min CBR 80 @ 100% MOD or 65 @ 98% MOD - compaction 100% of MOD - GM min 1.75 - PI max 12 Subbase - min CBR 30 @ 95% MOD - compaction 97% of MOD TOF (top 150mm) - min CBR 15 @ 93% MOD - compaction 93% of MOD Fill - min CBR 3.0 @ 90% MOD - compaction 90% of MOD		The laden axle load is about 50% higher than a normal standard E80 load but the tyre pressure is significantly lower. This pavement can easily carry this type of loading.
	NOTE: **A minimum of 3 days notice must be given for a reply by the Project Engineer**		☑ Response ~~will~~/will not* lead to a Design Change ☐ Minor Change will be effected via Drawing Amendment Sheet Ref No ☐ Major Change will be effected via re-issue of the Design Data (Drawings, Specification etc)
	Additional sheets appended Y/N: N **If yes, state total number of sheets:** **Date that response is required by:** ASAP		**Additional sheets appended Y/N:** **If yes, state total number of sheets in reply:** **Response made after ref. to (name):**

Close out

(After relevant work completed) TQ: ☐ Affects as-built records ☐ Does not affect as-built records.

TQ: ☐ Implemented in full ☐ Not implemented ☐ Partially implemented as described below:

By: Signed: Date:

Query dispatched byARE	Name:		Signed:		Date:	
Query received by Resident Eng.	Name:	Jason Nash	Signed:	JSN	Date:	04/05/2005
Response dispatched Project Eng.	Name:	Nick Kong	Signed:		Date:	09-May-05
Response received by Contractor	Name:		Signed:		Date:	

* **Delete as appropriate**

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APPENDIX Q: EXAMPLE FOR TEMPLATE OF SITE DIARY

LOGO/ COMPANY NAMES	SITE MANAGEMENT SYSTEM FOR ROAD CONSTRUCTION	DAILY SITE DIARY

CONTRACT No: PROJECT No

ER: DATE:

RAIN: None (mm) .....°C Max .....°C Min

TIME OF RAIN (Duration) ..... WINDY? ☐ Y ☐ N DUSTY? ☐ Y ☐ N

CHANGES TO:

	ITEM	+	-		ITEM	+	-
PLANT				PERSONNEL			
OTHER				OTHER			

INCIDENTS / SAFETY

.....

.....

Is the Contractor working safely? ☐ Y ☐ N

WORK STARTED / RESTARTED / COMPLETED *(What did they do, when? Only positive reporting)*

.....

.....

.....

.....

.....

.....

.....

WORK TEMPORARILY SUSPENDED / DELAYS / DISRUPTIONS / POTENTIAL CLAIMS

.....

.....

GENERAL

.....

.....

DEVIATIONS

Has the Contractor supplied his daily report on the state of all deviations? ☐ Y ☐ N

Are all deviations safe for use by the travelling public? ☐ Y ☐ N

If NO, give details: .....

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APPENDIX R: EXAMPLE OF WEEKLY MEETING

STAFF MEETING NO. 20

PROJECT: C1000 Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)

DATE AND TIME: Tuesday 08th September 2020 AT 09:00 Site Office

ATTENDANCE: S. De Lange, W. Mahobja, J. Bongani.

LEAVE / HOLIDAYS: Public holiday on 24th and pay weekend on 25th of September 2020.

Site Instructions:

- No. 50 – Drainage on MR540.
- No. 51 - Temporary access road at km 76,22 LHS
- No. 52 - Service ducts
- No. 53 - Seal design (winter)

DISCUSSION:

1. The RE asked if anyone has contacted with someone tested positive, if so, rather stay away from work until you feel better. We must always protect ourselves by wearing our masks.
2. The RE also emphasised the importance of the visual inspection.
3. Staff member to take responsibility for supervision their construction team, visual inspection, completion of checklist, worksheets, evaluation and signing off test requests.

DUTIES AND RESPONSIBILITIES:

S. de Lange:

1. Site instructions and site correspondence.
2. Monitoring progress and quality.
3. Farm excesses and bell mouths.
4. Quality control and signing off the registers spread sheets.
5. Minutes of site meetings.
6. Daily dairy.
7. Certificates.

W. Mahobja:

1. The process mapping of texture slurry.
2. Rolling straight edge and 3m straight edge.
3. Pre-marking and the road stud.
4. Shoulder cleaning.
5. Construction of edge beam.
6. To check on slurry.
7. Mark the patches.
8. Minutes of the staff meetings.
9. Block paving at Grootdrif.

J. Bongani:

1. Traffic sign inspection & dashcam once a week.
2. Signing of road reserve cleaning register, TSO.
3. Prime coat and Seal work.
4. G3 base.
5. Minutes of technical meeting.

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APPENDIX S: TEMPLATE FOR BILL OF QUANTITIES

Consultant	QUANTITY MEASUREMENT
CONTRACT NO. C1000	CONTRACTOR : Construction A
Rehabilitation of Road X from destination A (km 0.0) to destination B (km 12.5)	

ITEM DESCRIPTION:	SCHEDULE B
GENERAL REQUIREMENTS AND PROVISIONS	
Protection, removal, realignment and replacement of services	items No.:
(a) Traffic monitoring stations	B12.01
(i) The removal, protection and replacement of CTO, SMD and WIM installatic	PAGE ..... OF .....

UNIT: P C Sum	BILLED QUANTITY: 1	RATE : 2 000.00
ESTIMATE QUANTITY		AMOUNT: 2 000

DATE	CERT	DESCRIPTION/DIMENSIONS	REF	MEASURED QUANTITY	CUMULATIVE TOTAL	SIGN CONT	SIGN RE

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