CONSTRUCTION MANUAL

1ST EDITION

OCTOBER 2014

This document has been prepared for the Roads Authority of Namibia for the exclusive use of the Roads Authority and Consultants employed by the Roads Authority.

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Preface

The Roads Authority of Namibia is a statutory body established in terms of the Roads Authority Act, Act 17 of 1999.

Section 3 of the Act sets out the object of the Authority as follows:

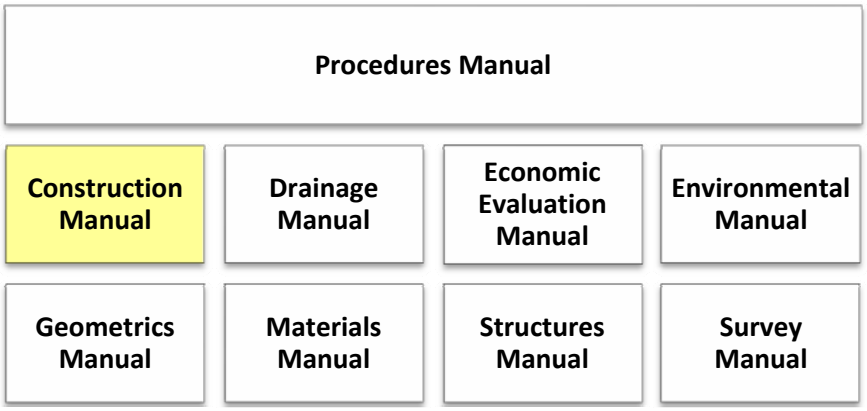
"Subject to this Act and the Road Fund Administration Act, the object of the Authority is to manage the national roads network in accordance with section 16 with a view to obtaining a safe and efficient road sector."

It is important to understand that "efficient" includes economic and financial efficiency as well as the common understanding of the word.

Key clauses of the Roads Authority Act that are of particular relevance to operational issues are Section 15 wherein the Roads Authority's functions are set out; and Section 16, which elaborates on one of these functions that being the management of the national road network including inter alia:

- The planning, design, construction and maintenance of roads;
- The quality control of materials required for the construction and maintenance of roads;
- The supervision of work contracted out; and
- The prescribing of minimum standards to achieve a safe road system and cause the least possible disruption to the environment.

These four aspects of the Roads Authority's mandate are complex and wide ranging. In order to assist it to comply with these obligations, the Roads Authority commissioned a suite of manuals applicable to road work and related matters. It consists of the following interlinked units:



The Geometrics Manual is supported by the **Standard Drawings** and the **Traffic Signs Policy**.

Additional manuals, such as a Maintenance Manual, may in future be required.

The Procedures Manual

The Procedures Manual is the controlling document of the suite of manuals depicted above. It describes the duties and responsibilities of consultants contracted to the Roads Authority for the preparation of designs, tenders for, and supervision of construction of roads by contract. It is also relevant to other projects such as feasibility studies and other investigations and studies carried out on behalf of the Roads Authority. In short, it is relevant to all projects carried out by external service providers for the Roads Authority.

Roads Authority personnel carrying out similar functions are also subject to the requirements of the Procedures Manual.

The manuals in general

The purpose of the suite of manuals is three-fold:

- To provide a basis for the attainment of uniformity of action of all persons carrying out design and related work for the Roads Authority, whether these be in-house personnel or external consultants;
- To promote the attainment of uniformity between in-house personnel and external consultants in the handling of construction projects.
- To set out the minimum standards and requirements of the Roads Authority, either directly in a specific manual or through its linkages with the other manuals in the suite.

These manuals are to be seen as books of reference and instructions to be used in the planning, design and administration of projects.

Both relevant in-house personnel and all consultants are therefore expected to make themselves thoroughly familiar with the contents of the Procedures Manual and such other manuals as may be relevant to a project, so that each project can pass through the different stages of planning, design, tendering and construction satisfactorily and that the submission of reports, records, drawings, documents, etc. is according to requirements.

Consultants must supply copies of relevant manuals to each designer and Engineer's Representative employed on construction contracts for the Roads Authority, which latter copies shall be kept at each Site Office.

Should any portion of this manual appear to be contradictory, either internally or in relation to any other manual; or insufficiently detailed, the Project Control Engineer must be contacted for a ruling.

Constructive criticism and suggestions for improvement of any of the manuals would be appreciated and should be addressed to:

The Chief Executive Officer, Roads Authority, Private Bag 12030, Windhoek, Namibia

with a copy to the Project Control Engineer.

Access to the manuals

The manuals can be downloaded from the RA website at: www.ra.org.na The RA will only upload the current amendment of the manuals on the site. It however remains the responsibility of the Consulting Engineer, upon his appointment, to confirm with the Project Control Engineer that the manuals on the website are the versions required for his specific appointment.

Definitions

The following definitions are relevant to all manuals:

Agreement	is the completed Agreement between the Roads Authority and the Consulting Engineer. Such Agreements may have different titles, depending on the source of funding.
Chief Executive Officer	is the person appointed under Section 14 of the Roads Authority Act to serve as Chief Executive Officer of the Roads Authority.
Date of Agreement	is the date on which it was signed by the last person signing.
Engineer	is the Consulting Engineer appointed by the Roads Authority to prepare a project or contract documents, or to supervise the execution of a contract.
Ministry	The Ministry of Works and Transport of the Government of Namibia
Permanent Secretary	is the official appointed to the post of Permanent Secretary of the Ministry of Works and Transport
Project Control Engineer	is the official appointed by the Chief Executive Officer to coordinate the execution of a specific project and to act as a link between the RA and the Consulting Engineer.
Roads Authority	is the Roads Authority constituted in terms of the Roads Authority Act, Act 17 of 1999

Guidelines for users of the manuals

The following icons are used throughout this edition of the Manuals:

CAUTION – This icon, usually accompanied by highlighted text, indicates that the user must be aware and use caution when following certain procedures or deviating from standard design methods.

YIELD – This icon indicates that the Roads Authority must be informed of an issue. This might be a deviation from the Terms of Reference; a deviation from design standards; or the achievement of milestones. Work may however continue.

STOP – Unlike for the yield icon, the stop icon indicates that the Roads Authority's written approval must be obtained before commencing with any further design or other tasks related to the issue for which approval is to be obtained.

NO ENTRY – This icon indicates no-go areas for practitioners. These could be set values for certain variables, or certain processes that may not be followed.

WORK IN PROGRESS – The "men at work" icon is used where sections can and should be extended or where work is pending. Due to funding or time constraints these parts or sections are not yet included in the manual.

Copyright of work done by the Consulting Engineer

All field books, data, calculations, plans, reports and tender documents produced in consequence of an appointment by the Roads Authority to carry out work in terms of these Manuals, become and remain the property of the RA upon submission of these items to the Roads Authority.

Acknowledgement

In preparation of this and the other manuals comprising this suite of manuals applicable to road works, considerable use, including direct application, has been made of similar work done previously by the predecessor in title of the Roads Authority and by other authorities, notably the manuals, directives and memoranda of the Western Cape Provincial Administration (South Africa), the Department of Transport (South Africa) and the South African National Roads Agency Ltd (SANRAL). These sources were used with due permission. The Roads Authority acknowledges with thanks the valuable content from these non-Namibian sources used in the Manuals, as well as that from Namibian sources such as the Meteorological Services, the Ministry of Environment and Tourism and others. It goes without saying that the Roads Authority also acknowledges with thanks all individual authors who contributed to the source documents from which content has been taken for use in these manuals.

In respect of materials and pavements, permission to use the South African Pavement Engineering Manual (SAPEM) was provided by SANRAL. This Manual was however not available until completion of this suite of Procedures Manuals of the Roads Authority. The reader is nevertheless referred to this comprehensive Manual for further reading. With constant developments towards more sophistication in testing methods - including advances in computerised testing equipment – and the introduction of new design and construction technologies in the Southern African Roads Industry, the Roads Authority will study the implications of deviations included in the SAPEM Manual and will inform the industry in Namibia when adjustments to this Construction Manual will become necessary.

Particularly the current revision of TMH1 into SANS 3001 standards, the introduction of SANS 4001 and the re-writing of the Standard COLTO Specifications (1998 edition) will have a direct impact on materials testing, planning, design and construction in Namibia. A table which indicates the corresponding SANS 3001 standards already prepared are included in Annexure E of the Materials Manual. Guidelines on the application of these new standards in Namibia will be notified by the Roads Authority in due course.

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Glossary of terms

General Conditions of Contract	Conditions of Contract for Construction for Building and Engineering Works Designed by the Employer, published by FIDIC
Particular Conditions of Contract	Project-specific Conditions prepared to explain, amplify or replace clauses of the General Conditions of Contract
Project Specifications	Project-related Specifications in which clauses of the Standard Specifications are explained, amplified, or replaced
Standard Specifications	Standard Specifications for Road and Bridge Works for State Road Authorities prepared by COLTO and published by SAICE, referred to in short as "COLTO"
Mod AASHTO	Modified AASHTO test to determine Maximum Dry Density (MDD)

Abbreviations

AA	Automobile Association
AASHTO	American Association of State Highway and Transport Officials
CBR	California Bearing Ratio
DEO	Designated Environmental Officer
FIDIC	Fédération Internationale des Ingénieurs-Conseils
COLTO	Committee of Land Transport Officials
CSSACS	Conventional slow-setting anionic coarse slurry
G1 to G10	Granular materials classification according to TRH14
GCC	General Conditions of Contract
ICS	Initial Consumption of Stabiliser
ITS	Indirect Tensile Strength
MDD	Maximum Dry Density
MTV	Material transfer vehicle
PCE	Project Control Engineer
ppm	Parts per million
RA	Roads Authority
RE	Resident Engineer

RSRMCS	Rapid setting rubber-modified coarse slurry
SANS	South African National Standards
SHE	Safety, Health and Environmental officer
TMH	Technical Methods for Highways
TRH	Technical Recommendations for Highways
UCS	Unconfined Compressive Strength

1 INTRODUCTION

1.1 General

No matter how well the design of a bridge or road is executed, in practice it is only as good as the quality of the construction of the facility allows. Good design can be rendered useless or ineffective by poor construction. On the other hand, the construction phase of a project also affords the Consultant a final opportunity to recognise flaws in the design and to correct these in time.

There are good contractors and others that are not so good, and still others that are inexperienced for the work at hand. The tender process used by the Roads Authority (RA) should ensure that a contractor appointed for a RA project will have adequate experience and sufficient capital and equipment to carry out the work. However, the ultimate success of a construction project lies more in the attitudes of the various protagonists and in this respect, the manner in which the Consultant's site staff carry out their monitoring role will play a crucial role in determining the outcome of the project.

The purpose of this Construction Manual is to outline the process for the monitoring of construction work with particular reference to activities and the interaction between the various parties involved in the construction work. The standard and project specifications specify actions, activities and requirements for quality control. It is not the intention to duplicate these matters here, but rather to amplify where necessary and cover aspects specifically not covered by the abovementioned documentation.

Where the Consultant operates in terms of a Quality Management System, this manual must be read in conjunction with the latter. In order to avoid the potential for a large degree of conflict between this manual and the management systems of consultants, the emphasis herein has been in general on what the RA expects must be done rather than on how things are to be done.

2 HEAD OFFICE AND THE SITE

2.1 Personnel

The point of contact between the Consultant and the RA will at all times be the Project Control Engineer (PCE). His duties are described in the Procedures Manual. Occasional contact with the Senior Materials Engineer in charge of the RA's Control Laboratory is also possible from time to time in regard to duplicate samples, but always with the knowledge and consent of the PCE.

The Consultant's personnel will in the first instance have been determined by the Terms of Reference for the project, thereafter by the Consultant's Technical Proposal for his tender and finally by the outcome of any negotiations which may have taken place between the RA and the Consultant regarding the tender. In all cases however, the project will be controlled at head office level by "The Engineer" as defined in the Conditions of Contract and on site by the Resident Engineer (RE).

The Contractor's personnel is not of any particular interest at this point, except to note that its member of staff responsible for the project, often designated the Contract Manager, will be the Engineer's formal point of contact with the Contractor, whereas at site level, the Contractor’s Representative usually known as the Site Agent will be the point of contact for the RE.

Figure 2-1 shows a generic organigram for a typical RA construction project. It is important to note that the nature and size of the project will determine which of the posts are filled. There may also be more than one incumbent for any particular post. One possibility is that a separate Project Engineer may be required on a specific project, in which case certain duties of the Engineer will have to be delegated in writing to the Project Engineer as for the RE in Clause 2.5 hereof.

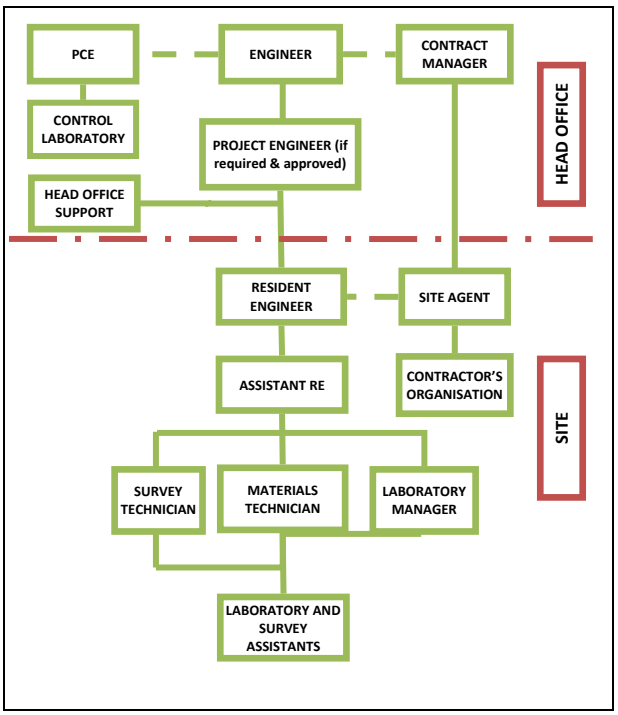

Figure 2-1 : Typical construction project organigram

2.2 Site offices, laboratory and accommodation

It is advantageous to locate the offices and laboratories of the Contractor and the RE together, for ease of communication. There may or may not have been typical plans in the tender documents for the Engineer's site office and laboratory. If so, the RE will at the start of the contract refine those plans to suit the circumstances taking into account the nature of the buildings offered by the Contractor. If not, the RE must request a proposal from the Contractor based on the billed items for the Engineer's office and laboratory and will then assess this proposal in the light of the circumstances and his requirements.

Housing may consist of prefabricated units erected by the Contractor; rented units procured by the Contractor; or in rare cases, may be houses owned by the Engineer's staff. In the first two cases, the provision of services is included in the contract. In the third case, a rental will be paid to the person concerned, but no services will be supplied under the contract.

2.3 Compensation

The question of compensation is usually handled by the RA before the start of the contract. In some cases payment of compensation will be handled through the contract.

The RE must be made aware of compensation issues that have already been dealt with as well as his responsibilities in respect of the compensation issues that must be dealt with during the contract, if any.

2.4 Environmental matters

A meeting must be arranged between the Engineer, the RE and the Environmental Assessment Practitioner utilised by the Consultant for the project. The objective of the meeting will be to discuss the Environmental Management Plan in general and specifically the requirements for opening and subsequent closing of the designated quarries, borrow pits and spoil sites. The procedure to be adopted in case it becomes necessary to open a quarry, borrow pit or spoil site not covered by the Environmental Management Plan must also be discussed.

2.5 Authority of the RE

The Engineer and the RE must ensure that the latter is in possession of a written delegation of authority in terms of Clause 3.2 of the Conditions of Contract before any work commences on the site.

Copies of this delegation must be sent to the PCE and the Contractor.

3 COMMENCEMENT OF THE WORKS

3.1 Site Handover

The Consultant must arrange for his site staff to be fully informed about the design concepts and parameters as well as any important or sensitive matters that need to be taken account of during construction.

A meeting must thereafter be held by the Engineer to hand over the site to the Contractor. At least the Contractor's Contract Manager and Site Agent as well as the RE and his senior materials technician must be present. The PCE and at his discretion the Regional Engineer should be invited. The purpose of the meeting is to formalise the commencement of activities on site and to agree upon the manner in which the administration of the contract at site level will be handled.

Annexure A contains a check list of typical items that must be covered at the site handover meeting. This list must be expanded or reduced to suit the specifics of the contract.

3.2 Liaison with landowners or occupiers

As soon as possible after commencement the RE and the Site Agent must together visit all landowners or occupiers affected by the Works to hand over notifications in respect of entry onto private property as required by the Roads Ordinance, and to explain in general what will be done and the timing thereof.

If materials are to be sourced or spoiled on a property, the landowner must be informed about haul roads that will be constructed as well as how these and quarry or borrow areas will be rehabilitated.

The question of the effect of construction activities on livestock and other agricultural activities - and where relevant wild animals - must be discussed and where appropriate, effective solutions devised. It is equally important to deal with the effect of livestock and wild animals on the construction activities, especially in cases where the road reserve is not or will not be fenced.

Each person visited must be given the RE's contact details and a reporting procedure for use in case any construction-related problems arise. The Landowner Release Form (which will become the Clearance Certificate) must be shown and its purpose explained to each landowner or occupier.

3.3 Liaison with local authorities, police and service authorities

The RE and the Site Agent must, as soon as possible after commencement of site activities, together visit the local police, traffic police, affected Municipalities, the Regional Governor's office and its local counterpart if any, relevant service authorities and the RA's Regional Engineer with a view to informing them about the contract, how they might be affected, requesting their understanding and cooperation and giving them contact details of the Site Agent and RE.

The Regional Engineer, and where relevant for specific meetings the traffic police as well as selected relevant other local and service authorities, should be invited to attend the monthly Site Meetings.

3.4 Working hours

In general, it is expected that the RE and his staff must be on site for the same hours as worked by the Contractor, in order that there may be full inspection of the Works. If the Contractor works excessively long hours or at weekends, the RE must make arrangements to stagger the working hours of his staff to ensure that the Works are properly monitored.

If it is necessary for the RE to absent himself from the site for whatever reason, the Site Agent must be informed in writing together with details of how the duties of the RE that directly affect the Contractor will be handled during his absence.

3.5 Setting out

The RE must ensure that the beacons and benchmarks necessary to enable the Contractor to set out the Works are available, with no obvious signs of disturbance. He must then formally hand over the beacons and benchmarks to the Contractor whose responsibility they will then become. The Contractor must check these items and report any discrepancies to the RE who will arrange for such problems to be resolved.

Once the Contractor has set out the Works, the RE must conduct independent checks to satisfy himself as to the adequacy and accuracy of the setting out.

3.6 Health and Safety

The responsibility for the health and safety of the public and the Works rests with the Contractor's appointee as the "Responsible Person" in terms of the relevant legislation. All accidents must be reported in writing to the RE as well as to any other recipient defined in the legislation. The Engineer, the RE and his staff have a duty to notify the Contractor and if necessary order him to stop work whenever they become aware that the health or safety of any person or the Works is at risk, but the responsibility for rectifying the risk rests with the Contractor.

The RE and the Site Agent must determine an appropriate modus operandi to deal with health and safety matters as soon as possible after commencement of work on site.

The Contractor is required to appoint a member of his staff as the Designated Environmental Officer (DEO) (see C1005 of Annexure C of the Environmental Manual). It is often convenient for the same person to act as the "Responsible Person" and as the DEO. In such cases the appointee is often designated as the Safety, Health and Environmental Officer (SHE).

4 COMMUNICATION

4.1 Resident Engineer – Contractor

4.1.1 General

In order to carry out their duties effectively and achieve the smooth progress of the Contract, it is essential that there should be a good working relationship between the Resident Engineer, his staff and the Contractor's site staff at all levels.

In addition to looking after the specific interests of the RA and the Engineer, it is essential that the Resident Engineer appreciates the importance of the mutual interest of the RA and the Contractor in the timely completion and in the financial outcome of the project.

At the commencement of a project, the Engineer's knowledge of the Works is normally much greater than that of the Contractor. It is essential that the RE ensures that he is fully conversant with the project at the outset so that he can help resolve the initial difficulties of the Contractor and thereby obtain his goodwill from the start. The RE must avoid taking a detached and critical stance towards the Contractor. On the other hand, the adoption of a positive and helpful role does not mean that he must usurp the Contractor's responsibilities.

4.1.2 Duties and Powers of Resident Engineer

The duties and powers of the RE are indicated in Clause 3(2) of the Conditions of Contract, but his main authority derives from delegation to the RE of any of the powers and authorities vested in the Engineer. The RE must ensure that he is clear as to the powers, if any, which have been delegated to him.

Any such delegation must be notified to him, the RA and the Contractor in writing, and he must formally accept the delegation by signing a copy of the letter of delegation and returning it to the Engineer.

Contract documents are drawn up to cover a wide range of eventualities and the RE is expected to use his discretion in their application. He may not, without the approval of the Engineer, change the design or the specifications or give rulings on legal issues.

The Contractor tendered on the basis of a specification and is under no obligation to exceed its standards, especially when to do so would lessen the profitability of the project. The RE must realise that to expect strict adherence to the specifications is to enter the realm of perfection so he must be prepared to consider the Contractor's proposals for rectifying mistakes and faulty workmanship. However, no remedial work which he considers would constitute a departure from a correct interpretation of the specifications should be permitted without the prior approval of the Engineer.

The RE must deal fairly with the Contractor's measurements and claims for payment and must not allow opinions and prejudices to obscure the facts. If he finds he is unable to reach an amicable settlement of a disagreement with the Contractor's Site Agent, he must present a balanced and factual report to the Engineer.

The presentation of the facts relevant to claims made by the Contractor is an important part of the RE's duties. He must therefore have a complete and detailed knowledge of the contract documents. Where he has any doubt as to the correct interpretation of any document he must seek clarification from the Engineer at once. This will ensure that he can state at all times with confidence what the Engineer's intentions are in case the Contractor attempts to adopt a different interpretation.

4.1.3 Site Instructions

The golden rule is that "a written communication is an instruction whereas an oral communication is a suggestion".

Formal communication between the RE and the Site Agent will take place in the form of site instructions and usually involves matters of a contractual or financial nature not considered as requests or questions and answers normally associated with the routine running of the site.

In general, instructions must be given by the RE in writing, to the Site Agent only. Oral instructions must be confirmed in writing in Site Instructions. Only in cases of emergency or where a prior written agreement between the RE and the Site Agent is in place, may members of the RE's staff issue instructions to the Contractor.

Copies of all Site Instructions and Site Requests must be sent to the Engineer on a monthly basis.

4.1.4 Site requests

Matters not covered under 4.1.3 must be recorded in a duplicate book divided down the middle with one side for the RE and the other for the Site Agent. These items are usually routine requests or questions and answers normally associated with the running of the site.

4.1.5 Submissions and approvals

This is divided between the following three elements of the Works.

4.1.5.1 Constructed Layers

The Contractor is required to submit proof that he has carried out the required materials tests and survey work to demonstrate that the constructed layer, wherever it may lie in the Works, conforms to the specified requirements when requesting acceptance testing by the RE. The request for testing (see Annexure B for a typical submission form) together with the abovementioned proof is to be submitted by the Contractor to the RE's laboratory. The technician must then approve or reject the request within 12 hours if visual inspection only is required or within two days if laboratory testing is required. If tests that require more time are required (for instance CBR), then the layer, if otherwise compliant, should be accepted within the given time limit, subject to the outcome of the tests in progress. In the case of rejection the reasons must be stated on the form.

In borderline cases the test results will be referred to the RE for a decision.

All approvals must be recorded on a progress chart.

4.1.5.2 Structures

A formal request must be submitted by the Contractor to the RE's laboratory requesting approval to pour concrete and the expected time of the pour. (See flow diagram and typical submission form in Annexure B). The technician must approve or reject the request within 4 hours of the time of submission. The reasons for rejection must be stated on the request form.

The technician will make the necessary concrete cubes for strength testing and maintain a record of 7-day and 28-day results. In the event of failure at 7 or 28 days the technician will inform the Contractor and the RE in

writing. If the 28-day strengths are unacceptable, the RE will request proposals from the Contractor to remedy the problem. The RE will consider the Contractor's response and give a formal ruling as to whether the work is rejected or accepted, possibly at partial payment.

All prefabricated items shall be tested in accordance with the specification by the manufacturer and the test results proving compliance will be required by the RE before acceptance.

4.1.5.3 Other works

All other works e.g. fencing, trimming etc. are to be submitted for approval via the site request book. These requests will be dealt with by the RE or delegated staff member within a 24-hour period.

4.2 Supervisory staff and the Media

The RE and his staff are not permitted to make or issue statements to the media or insurance companies.

All requests for information are to be referred to the Engineer who will refer them to the PCE.

4.3 Resident Engineer – Landowners and local communities

After the RE and the Contractor have made initial contact with the landowners, local authorities and the like, direct contact may be made by the Contractor provided that the RE is informed.

4.4 Visitors

All visitors to site other than appointed staff shall report to the office of the Site Agent in order to sign the visitor's book and to receive instructions regarding site rules.

5 MEETINGS

5.1 Monthly site meetings

5.1.1 Introduction

Clause 1227 of the Standard Specifications requires that monthly site meetings be held. The following matters are dealt with in 8.4 of the Procedures Manual:

- Purpose of the meetings
- Representation at the meetings
- Position of representatives of the RA at meetings
- Standard Agenda

5.1.2 Inspection of the site

The meetings must be preceded by an inspection of the site. The PCE, the Engineer, the Resident Engineer and the Contractor usually inspect the project together, calling upon other staff members to accompany them if something specific and problematic is to be inspected.

5.1.3 Chairman of the meetings

The meetings must take place under the chairmanship of the Engineer. In the case of the unavoidable absence of the Engineer due to some unavoidable situation, the meeting is to be chaired by the Resident Engineer.

5.1.4 First site meeting

The first site meeting differs substantially from the subsequent ones in that there will be little if any progress to record and few if any problems to discuss. On the other hand it will be necessary devote considerable time to establishing the ground rules regarding working relationships and procedures to be followed.

5.1.5 Minutes of site meetings

As stated in the Procedures Manual, site meetings do not form part of the formal contract administration and it follows that the minutes do not do so either. However the minutes remain important as they record that items have been discussed.

Instead of discussing items brought forward from previous meetings at the start of a meeting, it is convenient to discuss them as the first items under the agenda headings under which they resort and have previously been minuted.

The RE is responsible for producing the draft minutes of each site meeting. He must request clarification during the meeting if he is in doubt about the phrasing of any matter, particularly if it is contentious. When completed, the draft minutes should be countersigned by the Site Agent as an indication of acceptance of the content and submitted by the RE to the Engineer within 5 days of the meeting. The Engineer must check and if necessary rectify the minutes.

Every item raised must be given an identifying number, the first digit(s) of which will be the number of the site meeting. This must stay the same in subsequent meetings until the matter has been resolved. Whenever an item has been resolved, the entry in the minutes must end with the words “Matter resolved” and the item must not recur in subsequent minutes.

The minutes must be meaningful and must indicate clearly who is expected to take action on a particular subject. A column must be provided on the right-hand side of the paper for use as an action column. Action should be limited to the Contractor, the Consulting Engineer, the Resident Engineer and the PCE.

The minutes must be accepted at the next site meeting after any necessary amendments have been recorded and a copy signed as a true record by the senior members present of the RA, the Consultant and the Contractor. The signed copy of the minutes must be retained by the Consultant.

5.1.6 Distribution of the minutes

Minutes of the Site Meetings must be distributed by e-mail preferably within 7 days, but at least within 14 days, of the meeting by the Engineer to the following:

- The PCE (who is responsible for further distribution as may be required within the RA)
- The Regional Engineer
- The Contractor's Head Office
- The Site Agent
- Resident Engineer
- Other Authorities/Visitors (relevant sections of the minutes only)

5.2 Other meetings

When matters of a relatively high technical or administrative nature have to be discussed, it is useful to hold other meetings usually designated as Technical Meetings, prior to the site meetings. There can be a wider representation at a more specialist level at such meetings. The conclusions reached at such meetings can be brought forward and dealt with at the formal site meeting.

The RE and the Site Agent will also hold regular meetings to discuss routine matters such as progress, quantities and planning of the Works. Relevant staff of both the RE and the Contractor will also attend these meetings.

The RE will chair these technical and other meetings and will be responsible to produce and distribute minutes, including copies to the Engineer.

6 PROGRAMME AND PROGRESS

The Contractor has an obligation to submit a Works Programme within 28 days of receipt of the notice of the Commencement Date. The RE will be required to review the programme and submit his comments thereon to the Engineer for further action.

The programme is a very important document for the control of the Works; for the monitoring of progress and for the assessment of any claims which may arise. It is therefore necessary that the RE applies his mind fully when reviewing the programme. Annexure C may be found useful in this process.

Monitoring of the Contractor's performance in relation to the approved programme will be based on a comparison of programmed and actual figures for production rates, on percentage completion of items of work and by way of the Californian S-curves. Any deviation from the programme must be reported to the Engineer so that the matter can be discussed with the Contractor and remedial action instituted as necessary.

7 QUANTITIES AND PAYMENT

7.1 Measurement

It is the Resident Engineer's responsibility to measure the works, and to this end he must set up suitable systems for performing all measurements with the Contractor. The system adopted for carrying out interim measurements should be as simple as possible, but must also meet the main objective of ensuring accurate final measurements without unnecessary duplication of effort.

All quantity calculations must be made on standard sheets and kept in files reserved solely for this purpose.

Final quantities must be measured and agreed with the Contractor as soon as possible after an item has been completed. This ensures greater accuracy of interim certificates; avoids a concentration of final measurements and calculations at the end of the contract; and ensures that the calculations are done by persons familiar with the details. The contract should be broken up into sections demarcated by convenient features such as bridges or intersections in cases where an item of significant value will remain in use for long periods (such as fill). As the work for that item is completed in each such section, the final measurement of the item for that section should be agreed so that the value of work done for which the measurement has not been finalised is kept to a practical minimum.

If the Contractor is uncooperative in this regard a report must be made to the Engineer.

7.2 Payment Certificates

The format and handling of interim and final payment certificates is dealt with in 8.5 of the Procedures Manual.

Where the contract provides for price adjustment based on published indices, the RE must obtain the indices from the Engineer in order to check the Contractor’s submission. These indices are usually published some months in arrears. Extrapolated indices may be used until the indices are published in order to make provisional adjustment payments. Continual adjustment will therefore be necessary in subsequent

certificates in order to replace the extrapolated indices and correct the provisional payments.

If rise and fall adjustment is included, the Contractor must provide proof of price changes before payment may be made.

8 FINANCIAL CONTROL

This matter is discussed in 8.6.3 of the Procedures Manual.

9 HANDLING OF CLAIMS

9.1 Introduction

Owing to the complexity and sometimes indeterminate nature of civil engineering works it is not possible to produce contract documents which are perfect and deal with every eventuality. Thus claims from Contractors will arise.

Claims will be addressed to the Engineer who may or may not require input from the RE. The most important contribution which the RE can make to the settlement of claims is to ensure that agreement is reached on matters of fact ascertainable from his records. He may not rule on matters of principle or accept or reject a claim.

The matter of third party claims is dealt with in 8.7 of the Procedures Manual.

9.2 Payment

The RE may not allow the inclusion of payment for a claim until he is in possession of a copy of a completed and signed copy of the corresponding Variation Order.

10 REPORTS

10.1 General

Most of the routine reports required of the RE take the form of standard appendices to the monthly site meetings. Although many of these emanate from the Contractor, the RE is responsible to ensure that the reports are accurate. Other reports that will or may be required on a routine or ad hoc basis include:

- Environmental matters;
- Accident issues;
- Third-party claims;
- Control samples;
- Materials issues.

10.2 Contract report

10.2.1 Purpose of Report

A Contract Report is required in respect of every construction contract undertaken by the RA. Its purpose is to record all relevant information in a convenient form so that it is available for reference both in respect of the specific contract; as a source of information for future pavement rehabilitation and for general use.

10.2.2 Requirements during contract period

The Resident Engineer must be aware from the outset of the information required for the report so that he can assemble it during the course of the contract.

The Appendices to the Site Meeting Minutes will be found useful in the compilation of the report.

10.2.3 Contents of the report

The information to be included in the report is indicated in Annexure M of the Procedures Manual.

10.2.4 Presentation of the report

The report must be submitted in A4 size with a spiral binder and have a neat and tidy appearance. It must be concise but as complete as possible. Information already provided in the documents and other reports should not be repeated. Appropriate references should be made instead. An index must be provided.

10.2.5 Submission of the report

The report must be submitted in draft form to the PCE for approval within three months of the date on which the Taking-over Certificate for the whole of the Works is issued. When necessary, the draft report must be amended to include any relevant developments during the Defects Liability Period(s). The final report must be submitted to the PCE within one month of the issue of the Performance Certificate.

One paper and one digital copy of the draft and final reports are to be submitted.

11 RECORDS

11.1 Introduction

Nothing is more important than the keeping of adequate and accurate records. Records are important not only for the routine administration of the contract, but also for the handling of third party and Contractor's claims. Statistics garnered from the RE's records are of use to the RA and the Consultant long after the contract has been completed. Completeness and accuracy are therefore crucial.

11.2 Site diaries

The RE and his support staff must each keep a personal diary. They may not be used for personal notes. The records must be accurate and unbiased. No facetious or humorous comments may be made in these records.

A daily site diary must in addition be compiled by the Contractor and verified by the RE by comparing it with the personal diaries. The daily site diary must be agreed and signed by both the RE and the Contractor the following day, and must be regarded as an official part of the site records.

The following entries must be recorded in personal and site diaries on a daily basis.

1. **Weather:** The effect of weather conditions on the Works must be recorded. Should abnormal weather conditions occur (for this purpose defined as conditions worse than the average over the previous 10 years), this must be reported to the Engineer.
2. **Work in progress:** The work carried out on the various sections must be recorded. Special note must be taken of progress on work lying on the critical path. Plant and equipment breakdowns must be listed with particular mention of items which could affect the completion of the project on time.
3. **Commencing and ending dates of operations:** The dates on which major items such as excavation, drainage, earthworks layer work and surfacing commenced and ended in particular sections of the contract must be recorded.

4 **Matters concerning services:** Every discussion with the various service authorities must be recorded. The diary record should state the name and department of the person concerned; whether there was a phone call or a site visit; the matter discussed together with details of information given or received and the outcome of the discussions.
Work carried out on services by the service authorities themselves must be recorded including the date commenced, daily progress and the date of completion. If the Contractor has been delayed due to services this must be recorded.

5 **Signage:** The presence and condition of road signs and especially those provided for traffic diversions must be recorded.

6 **Materials:** Records must be kept of materials inspected, of work approved or rejected, of matters relating to the standard of construction and of quarries and borrow pits open and closed.

7 **Equipment:** Detailed records shall be kept of all equipment on site, as well as the employment and availability (condition) thereof.

8 **Labour and Supervision:** Detailed records shall be kept of the number of labourers and supervisory staff employed by the Contractor, the activities for which these labourers and supervisors were employed as well as the duration of the specific activities.

9 **General:** A record should be kept of all visitors to the site. Queries from the PCE and Head Office staff should be recorded. Information regarding quantities, payment problems and claim investigations must be recorded.

11.3 Photographic record

After the site diaries, a good photographic record is the most important element of the site records. A photographic record in respect to the following situations must always be made. Other significant situations must also be photographed.

- The condition of elements of the site prior to the commencement of construction, particularly in respect of entrances, accesses, boundaries, fences, stream beds, any erosion which is evident, vegetation cover and any other aspect that is likely to become contentious.
- Work in progress in respect of both good workmanship and of unacceptable work.
- Damage to property.
- The completed work.

11.4 Record drawings

The RE must familiarise himself with the requirements of 8.11 of the Procedures Manual and act accordingly so that the necessary information may be collected as the work progresses.

11.5 Materials and bitumen records

The RE must submit to his Head Office the so-called Materials and Bitumen Control data sheets whereon the test results of layer and surfacing work constructed are recorded. These records must be updated monthly and kept on site for monthly inspection by the Engineer and the PCE. Progressive submission must be done on a 6-monthly or annual basis as agreed with the PCE.

12 COMPLETION PROCEDURES

12.1 General

The RE will play a leading role in the compilation of the lists of outstanding work (commonly known as Snag Lists) mentioned in 8.8.4 of the Procedures Manual. He must ensure that these are complete in all respects, since it is frustrating for the Contractor to believe that he has dealt with a snag list only to be asked to return on account of an item or items that the RE omitted to include in the list.

12.2 Landowner clearance certificates

The RA must be protected as far as possible from claims from landowners arising from the Contractor's activities being raised after the contract has been formally completed. To this end, it is essential that the RE visits each landowner affected in any way by the construction, after the Contractor has reinstated borrow pits, haul roads and other areas disturbed by the construction activities but before the relevant snag list is compiled. Any complaints raised by the landowner that can be attributed to construction activities must be added to the snag list and dealt with appropriately.

The landowner is not entitled to ask for anything or any standard of workmanship not covered by the specifications. On the other hand, care must be taken to comply with the Environmental Management Plan and the Standard Specification, even if the landowner would be satisfied with less.

Once the issues raised by the landowner have been dealt with, he/she or an authorised representative must be asked to sign a Landowner Clearance Certificate for the property, thereby releasing both the RA and the Contractor from any further responsibility in respect of the effects of construction activities. In the event that a landowner refuses to sign the clearance certificate, the Engineer must be informed immediately so that appropriate action may be taken in conjunction with the RA.

An example of a Landowner Clearance Certificate will be found in Annexure D. This may need to be modified to comply with the Environmental Management Plan for a specific contract.

13 SPECIFIC CONSTRUCTION ACTIVITIES

A number of construction activities are discussed in the following chapters in order to assist the RE and his staff in their daily tasks, especially but not only related to acceptance control. All concerned must read and understand the requirements for the activity in question, as set out in the Standard and Project Specifications and the Design Report with particular emphasis on the materials, accommodation of traffic and environmental components thereof.

Lists are given in each case indicating the minimum requirements of the RA for basic checking and if necessary rectification prior to acceptance. These must not be seen as complete in all respects. The Consultant is expected to add to these lists where necessary, either because he considers them to be incomplete or due to the special needs of the project. The term "all administrative work" used in the lists includes the technician keeping the RE informed; reporting results; keeping proper records; keeping a filing system dedicated to the activity; keeping "as-built" materials data up-to-date; keeping other data required for the record drawings up-to-date and calculating quantities as necessary.

Where relevant, the rate of acceptance testing expected by the RA is also given. The numbers of samples, tests, samples per lot etc. must be considered to be minima to be adjusted upwards if necessitated by the circumstances.

14 CONTROL OF CONSTRUCTION MATERIALS

14.1 General

The discussion in this section relates to naturally occurring materials to be utilised in the construction of the road. It is essential that the Resident Engineer and his staff are thoroughly familiar with the materials requirements of the Standard and Project Specifications.

Materials-related failures are almost inevitable during construction due to the variable nature of naturally occurring materials. However, the incidence of failures can largely be controlled by proper process control by the Contractor and by adequate supervisory control by the Consultant. It is embarrassing and indeed costly for all concerned to discover that material is substandard after a large volume of material has been stockpiled or even worse, dumped on the road. Even more expensive and time consuming is substandard material stockpiled after blasting and crushing.

Two basic principles that are sometimes overlooked are:

- The Consultant is responsible for locating, testing and ensuring availability of the natural materials to be used in the construction of the road; and
- The Contractor is responsible for process control during the procurement process and for ensuring that no material that does not meet the requirements of the specifications is taken to the road.

14.2 Scope of control

The Contractor's process control is outside the scope of this Manual. The Consultant is required to exercise control in four phases, these being:

- Checking the component materials of the layer or product prior to use;
- Verifying the materials design in the laboratory by checking the quality of the proposed material, including the design parameters set for the product or layer. It also covers the determination of the optimum level (target value) for the design parameters.
- Verifying the design by means of a formal trial section. This is mandatory in some cases as indicated in the following sections on specific construction activities. Where not so indicated, the RE must decide in the light of the information in the Materials Report and that gained from the work outlined in the previous two steps, whether to order a trial section. Separate payment is required for trial sections.
- Acceptance control of completed sections. The level of investigation required for this phase is outlined in the following sections. Where completion of a layer is referred to in the following sections in the context of proceeding to work on the next layer, this also implies acceptance of the layer by the Consultant. The test method, bench book, bench sheet and report form references in respect of most of the control testing required during construction will be found in the tables in Annexure E.

Pro forma forms such as covering letters, laboratory forms, field test forms, calibration test forms, report forms, control data sheets, statistical calculation forms, and MCD sheets can be downloaded from the RA's website.

14.3 Borrowpits and quarries

Some of the issues to be checked on a continuous basis in borrowpits and quarries are listed below.

- Delineation of the useable areas of the source;
- Proper clearing and if necessary grubbing of the delineated area;
- Proper disposal of cleared and grubbed material;
- Complete removal and proper stockpiling of topsoil and overburden in approved locations clear of future operations;
- Drainage of the source including prevention of inflow of surface water;
- Classification of borrow material;
- Use of plant appropriate to the task;
- Dealing with oversize material;
- Safety of excavated faces, including possible fencing of quarries;

- Safety of blasting operations including vibration damage to nearby buildings;
- Excavations not exceeding the designated depth;
- Separation of stockpiles of different materials destined for specific usage;
- Adherence to the Environmental Management Plan as applicable to borrowpits and quarries especially in respect of finishing-off after use.
- Obtaining a Landowner Clearance Certificate for each source.
- Water sources
- Check inter alia the following:
- Seasonal variation;
- Dissolved salts;
- Vegetable matter;
- pH.

Establish and/or do the following:

- Measure borehole yields at appropriate times;
- Report borehole extraction details to Head Office for transmission to the Department of Water Affairs.

15 ACCOMMODATION OF TRAFFIC

15.1 General

Ensuring the free and safe flow of traffic through the Works is an important part of the duties of the RE. Traffic includes pedestrians, cyclists and animals both driven and working. Generally speaking, the rights of public traffic take precedence over those of the Contractor, although circumstances will arise when public traffic will unavoidably be delayed.

15.2 Construction details

The Contractor must supply and the RE must approve, after any necessary adjustments have been made, a drawing showing all details of the geometry including intersections, and the pavement, wearing course, signs, barriers, flagmen, guardrails, drainage and any other pertinent detail of the diversion the Contractor proposes to construct, all as may be relevant. Depending on the circumstances, it may be prudent to discuss the details with the traffic police, especially in urban and other highly-trafficked areas.

The RE must specify the roadbed compaction required as well as the type and thickness of wearing course gravel to be used with due consideration given to the nature of the roadbed material, the nature and volume of the expected traffic (including construction traffic) and the expected service life of the diversion.

15.3 Notification

A week in advance of a traffic diversion or restriction being opened or removed, the RE must notify the Engineer who must notify the PCE of this. The PCE must in turn notify the Regional Engineer and the traffic police as well as the Automobile Association (AA). The RE must in addition notify the local radio and television stations, as appropriate, to inform the local public. The expected time and date of the start and ending of the diversion as well as any special factor such as a load restriction on a bridge must be supplied to these bodies.

15.4 Commissioning, maintenance and closure

Before allowing commissioning, the RE must check that the diversion has been constructed in accordance with the approved details and must arrange for the signs and road markings, if any, to be photographed before opening to traffic and thereafter on a weekly basis. He must also arrange for the signs and markings to be listed and the presence and condition thereof to be verified by the Contractor's Traffic Control Officer at the start and closure of each working day. Copies of these photographs and verification lists must form part of the RE's site records.

The RE is responsible for instructions concerning watering, blading, patching, regravelling, or resealing of the deviation surface, the frequency of which will be agreed with the PCE.

15.5 Accidents involving vehicles, pedestrians or animals

The RE must ensure that the Contractor's Traffic Control Officer draws up a formal report of any accident involving public traffic (vehicles, pedestrians or animals) where damage to property, injury or death occurred. Copies of these reports must form part of the RE's records. All such reports must be tabled for discussion at the next Site Meeting.

16 ROADBED

16.1 General

The roadbed is the natural in-situ material on which the fill, or in the absence of fill, any pavement layers, is to be constructed. Most stability problems in fill or in pavement layers in cut stem from poor roadbed conditions rather than from poor construction of the fill or layers as the case may be.

16.2 Checklists

Check the following as may be relevant and take the appropriate action:

- Clearing and grubbing for compliance;
- Topsoil removal for depth, width and stockpiling;
- Excavations for widths and levels;
- Presence of termites;
- Drainage of roadbed especially in cuts, including rock cuts;
- Evidence of wet areas and high water tables;
- Presence of collapsing sands, expansive clays, soluble salts;
- Presence of soft alluvial, estuarine or swamp soils;
- Presence of mine slimes dams.

Establish and/or do the following:

- Need for and type of roadbed compaction;
- Need for special tests;
- Need for removal of unsuitable material;
- Quantities or the survey data necessary for the later calculation of quantities;
- All administrative work.

Carry out design verification, by way of the following tests:

(Note that sampling frequency may need to be adjusted depending on the extent of the original soil survey, the material type and the exploratory work done in cuttings.)

- CBR (Sand at 100% and other material at 90% of Mod. AASHTO density) – 1 sample per 2000 m^2;

- In situ density - As per Project Specification;
- Moisture content – 1 sample per in situ density test;
- Grading - 1 sample per 1000 m^2 with a minimum of 3 samples per type of material.
- Atterberg limits – 1 sample per 1000 m^2 with a minimum of 3 samples per type of material;
- Special tests – as may be required for problem materials such as collapsing sands or expansive clays.

Carry out the following acceptance tests:

- MDD – 2 samples per 5000 m^2;
- In situ density – 1 sample per 1000 m^2 per layer with minimum of 5 samples per lot;
- Moisture content – 1 sample per test;
- Layer thickness – 1 per test point;
- Grading – 1 sample per 1000 m^2 with a minimum of 5 samples per lot;
- Atterberg limits – 1 sample per 1000 m^2 with a minimum of 5 samples per lot;
- Bearing strength and swell – 1 sample per 15000 m^2 with a minimum of 3 samples per material type.

17 CUTS

17.1 General

Lack of attention to drainage of the floors of cuts and to the presence of unsuitable material, particularly at the prick of the cut, are common sources of problems within cuts. Note that the RA requires that at least one layer of selected material must be placed through all cuts even if the material in the floor is hard.

17.2 Checklists

Check the following as may be relevant and take the appropriate action:

- Clearing and grubbing;
- Topsoil removal: depth, width, stockpiling;
- Drainage of cut floor;
- Width and excavated level;
- Geometry of side slopes;
- Loose material on side slopes;
- Excavation of side drains;
- Backfilling of over-excavation;
- Stability of spoil sites;
- Haul roads to point of use or disposal of excavated material.

Establish and/or do the following:

- Determine bulking and shrinkage factors
- Classification of excavation;
- Suitability of cut slope for material exposed by excavation;
- Quantities or the survey data necessary for the later calculation of quantities;
- All administrative work.

Carry out the following design verification and acceptance tests:

As for Roadbed.

18 FILLS

18.1 General

Fill consists of the imported material above the in situ roadbed and includes material imported to replace unsuitable material removed from the roadbed. Many fill problems are caused by lack of proper benching or by uncompacted material on the outside edges. The latter could be caused by indiscriminate dumping or cutting over the edge especially in side cut conditions, or by the safety concerns of operators of vibratory or impact rollers especially in high fill conditions.

18.2 Checklists

Check the following as may be relevant and take the appropriate action.

- Completion of roadbed;
- Condition of roadbed especially after heavy or prolonged rain;
- Setting-out of toe of fill;
- Toe drainage and benching;
- Geometry of side slopes;
- Compaction, especially at edge zones, plus number of passes of specified roller on rock fills.
- Lift heights;
- Oversize material;
- Sufficiency of fines in rock fills
- Haul roads from sources of materials.

Establish and/or do the following:

- Quantities or the survey data necessary for later calculation of quantities;
- All administrative work.

Carry out design verification by way of the following tests:

- CBR – as for roadbed;
- Grading and Atterberg limits – Frequency of sampling will depend on the extent of the original soil survey, the material type and the exploratory work carried out in cuttings and borrow pits.

Carry out the following acceptance tests:

- MDD – 2 samples per 500 m^3.
- Density – 1 sample per 100 m^2 per 150mm layer, with a minimum of 5 samples per layer per lot.
- Moisture content – 1 sample per test point.
- Layer thickness – 1 measurement per test point.
- Grading – 1 sample per 1000 m^2 per constructed layer thickness with a minimum of 5 samples per lot.
- Atterberg limits – as for grading.
- Bearing strength and swell – 1 CBR per 2500 m^3 with a minimum of 3 CBR's per source.

19 SELECTED LAYERS

19.1 General

A uniform product is required. This is sometimes not achieved due to lack of attention to operations in the borrow pit. Many borrow pits have significant variations in material properties. This means that care must be taken to identify the usable areas in the borrow pit. It may also be necessary to adopt specific methods of excavation, stockpiling and loading in order to achieve the desired result.

Other potential sources of lack of uniformity are lack of attention to mixing of materials from different sources, including the addition of soil binder to improve grading or reduce plasticity; and poor control of moisture content and distribution.

19.2 Checklists

Check the following as may be relevant and take the appropriate action:

- Completion of fill or roadbed as the case may be;
- Setting out;
- Correct dumping (start and finish points and spacing of heaps) of material including that to be mixed in (e.g. binder);
- Watering, mixing and placing;
- Potential for salt migration to upper layers;
- Compaction;
- Surface finish;
- Borrow pit operations;
- Haul roads from sources of materials.

Establish and/or do the following:

- Levels of finished layer;
- Shape, width and thickness of layer derived from levels (not dips).
- Quantities or survey data necessary for later calculation of quantities;
- All administrative work

Carry out design verification by way of the following tests:

- CBR – 1 sample per 1000 m^2, with a minimum of 5 samples per source;
- Grading and Atterberg Limits – 1 sample per 500 m^2, with a minimum of 5 samples per source.

Carry out the following acceptance tests:

- MDD – 2 samples per 500 m^2.
- Density – 1 sample per 1000 m^2 per 150mm layer, with a minimum of 5 samples per layer per lot.
- Moisture content – 1 sample per test.
- Layer thickness – 1 measurement per test plus additional measurements as necessary to verify thicknesses derived from levels.
- Grading and Atterberg Limits – 1 sample per 1000 m^3 per constructed layer thickness, with a minimum of 5 samples per layer per lot.
- Bearing strength and swell – 1 sample per 2500m^2, with a minimum of 3 per source.

20 SUBBASE

20.1 General

The remarks given in 19.1 apply equally to subbase.

Screening or single or multistage crushing may be necessary to eliminate excessive oversize material or to obtain a satisfactory grading.

The full-depth moisture content of untreated subbase must be 60% or less of the optimum moisture content before base is dumped on the subbase, unless the Project Specifications require the base to be placed earlier for reasons such as salt problems.

Incorrect curing of stabilised subbase is a potential source of problems especially in material susceptible to carbonation.

20.2 Checklists for untreated subbase

Check the following as may be relevant and take the appropriate action:

- As for selected layers, except that the first bullet point now refers to completion of the selected layer.

Establish and/or do the following:

- As for selected layers;

Carry out design verification by way of a trial section and the following tests:

- MDD – 6 samples per trial section;
- Density – minimum of 5 samples per trial section;
- Moisture content – 1 sample per test per trial section;
- CBR – 3 samples per trial section;
- Grading and Atterberg Limits – minimum of 5 samples per trial section;
- Shape (% fractured faces and flakiness in the case of crushed material) – 4 samples per trial section.

Carry out the following acceptance tests:

- MDD – 2 samples per 500 m^2;
- Density - minimum of 6 samples per lot;
- Moisture content - 1 sample per test;
- Layer thickness - 1 measurement per test plus additional measurements as necessary to verify thicknesses derived from levels;
- Grading, Atterberg limits and aggregate shape - minimum of six stratified random samples per lot;
- Bearing strength (CBR) - 3 per km with a minimum of 3 per source;
- Surface finish – visual assessment.

20.3 Checklists for cemented subbase

Check the following as may be relevant and take the appropriate action:

- As for selected layers, except that the first bullet point now refers to the completion of the selected layer;
- Application and mixing of stabiliser;
- Total time for mixing and compaction;
- Curing process;
- Traffic control on completed layer.

Establish and/or do the following:

- As for selected layers;

Carry out design verification by way of a trial section and the following tests:

- Grading, Atterberg Limits, % fractured faces (if relevant) and CBR of material in stockpile or dumped on the road – 1 sample per 2500 m^3 with a minimum of 6 samples per trial section;
- Atterberg limits – 2 samples per trial section;
- ICS, UCS, ITS, stabiliser content – minimum of 6 samples per trial section for each age of test being assessed, e.g. 3, 7, or 28 days;
- Durability – 1 sample per trial section;

Carry out the following acceptance tests:

- Grading, Atterberg limits and aggregate shape – minimum of 6 tests per lot;
- Bearing strength (CBR) - 3 per km;
- Stabiliser content - 5 canvas patch tests for bulk distribution of stabiliser or one calculation per lot if distribution is by pocket;
- MDD - 2 samples per lot;

- Density - minimum of 6 samples per lot, stratified random sampling;
- Moisture content - 1 sample per test;
- Layer thickness - as for selected layer;
- Strength (UCS/ITS) - minimum of six samples per lot, stratified random sampling (refer COLTO 8304; TMH5);
- Mixing uniformity - 6 holes per lot for visual assessment; also compare UCS results;
- Surface finish – visual assessment.

21 UNTREATED GRANULAR BASE (G2, G3 AND G4)

21.1 General

The remarks given in 19.1 apply equally to G3 and G4 base. In the case of G2 base, variations in the quarry can also occur for instance by way of seams of unsuitable material. Contamination of base with overburden material must also be guarded against.

The resilient modulus of granular base is very sensitive to moisture. Two possible countermeasures are moisture content control checks on the base itself and permeability checks on the surfacing. Before water rolling (slushing), the moisture content of the upper 100 mm of base must be less than 50% of the optimum moisture content.

The moisture-sensitive zone of 0.6 to 0.9 meter wide also occurs in the centre of the road. Care must be taken to ensure that moisture is not trapped in the base of the first half when sealing the second half of the road.

All the above-mentioned moisture checking must be carried out using a nuclear test gauge calibrated against gravimetrically determined moisture contents at a minimum of 6 reference points in a section of base with a moisture content of approximately 50% of the optimum moisture content.

A trial section is mandatory for every different type and source of base with a payment item allowed for in the Schedule of Quantities. These sections may be constructed as part of the subbase. The effect of salt migration into and through the base layer must be studied and addressed where material with a high saline content is used in the subbase or lower layers.

21.2 Checklists for G2, G3 and G4 base

Check the following as may be relevant and take the appropriate action:

- As for selected layer, except that the first bullet point now refers to completion of the subbase;

- Joint between base and shoulder material (no intrusion of shoulder material into or onto the base);
- Homogeneity (no segregation, especially of crushed material);
- Appropriate material for and compaction and finish of any base corrections.

Establish and/or do the following:

- As for selected layer.

Carry out design verification by way of a trial section and the following tests:

- As for untreated subbase.

Carry out the following acceptance tests:

- Moisture control - as outlined in 21.1;
- MDD – 2 samples per lot;
- Grading and Atterberg Limits – Minimum of 6 stratified random samples per lot;
- Density – minimum of 6 stratified random samples per lot (refer COLTO 8304; TMH5);
- Shape (% fractured faces and ALD) – 2 samples per lot;
- Full depth moisture (in addition to control as per 21.1) – minimum of 1 test per 100m randomly selected, but not less than 10 tests for sections longer than 1km or 4 tests for sections shorter than 1 km;
- Layer thickness – 1 measurement at each test point plus additional measurements as necessary to verify thicknesses derived from levels;
- Surface finish – visual assessment of mosaic over full area of lot plus rolling straightedge over full section;
- Bearing strength and swell – 1 CBR per lot (G4 base only).

22 WEARING COURSE AND GRAVEL SHOULDERS

22.1 General

The remarks given in 19.1 apply equally to gravel wearing course and gravel shoulders. Contamination of wearing course or shoulder gravel with overburden or other unsuitable material must be guarded against.

The selection of gravels with appropriate grading and plasticity levels is very important for these two layers, especially to reduce the incidence of erosion caused by surface water and the wind of passing traffic.

The design should aim for compliance with TRH 20.

22.2 Checklists

Check the following as may be relevant and take the appropriate action:

- As for selected layer, except that the first bullet point now refers to completion of the underlying layer, whatever that may be;
- Homogeneity;
- Joint between base and shoulder material (where relevant) – no intrusion of shoulder material into or onto the base.

Establish and/or do the following:

- As for selected layer.

Carry out design verification by means of a trial section if considered necessary and/or the following tests:

- As for untreated subbase.

Carry out the following acceptance tests:

- As for untreated subbase

23 ASPHALT BASE

23.1 General

A significant proportion of problems encountered in asphalt work, for instance variable and substandard density, unacceptable permeability and difficulty of compaction arise from poor control of the temperature of the placed material. Lack of control could result in the placed material being too cold in general or too cold in random areas. These problems can easily be rectified by attention to the detail of temperature control.

Another source of problems encountered in asphalt work is the lack of control of aggregate stockpiles and hot bin material. This control is normally done by the asphalt supplier but the RE must ensure that the following minimum testing is done and must in addition to verify the supplier's test results by way of testing in his own laboratory:

- Aggregates must be sampled from the delivery trucks or from dumped heaps in accordance with SABS 827.
- The frequency of sampling is to be approximately 1 per 400 m^3 and all the samples must be tested for grading and shape.
- When required the aggregate must also be tested for hardness, relative density and bitumen absorption.
- The dumped heaps must not be flattened until the test results have confirmed that the material conforms to the specification and is sufficiently uniform to consistently produce the required mix design.
- Hot bin samples are to be obtained by emptying the contents of a specific hot bin into a truck and sampling from the truck at a rate of one sample per bin per 400 tons of material mixed, but not less than once per day.

The laboratory mix design must be approved by the PCE, after which it must be verified by means of a trial section. This may lead to adjustments in the mix design and further trial sections until the job mix design is approved.

23.2 Checklists

Check the following as may be relevant and take the appropriate action:

- Preparation of base - adequacy of base corrections, acceptable moisture contents and intact prime or tack coat;
- Traffic control and safety measures;
- Presence of all necessary plant and equipment, including lighting for night work if necessary;
- Presence of sufficient trucks of asphalt to ensure continuous placing;
- Presence of tarpaulins on trucks;
- Temperature of mix just before tipping into the hopper and immediately before breakdown rolling.

Establish and/or do the following:

- Quantities or the measurements necessary for the calculation of quantities;
- All administrative work.

Carry out design verification by means of a trial section and the following tests:

- Before commencement and whenever there is a change in any of the components, a Marshall design and creep tests (dynamic creep modulus, cyclic creep modulus);
- Grading, Marshall design, creep moduli – 6 samples per trial section from behind paver;
- Mixing and supply temperatures – minimum of 1 temperature reading per load;
- Density – minimum of 6 x 100 mm diameter cores per trial section;
- Layer thickness, level and rolling straight edge – as may be appropriate to check functioning of sensor devices.
- Permeability – 6 Marvil tests per trial section, selected in suspect areas.

Carry out the following acceptance tests:

- Density - one test per hundred tons laid with a minimum of six tests per lot per day;
- Water permeability - minimum of 8 Marvil tests were not, but only if the density results are low. Otherwise one test per lot;

- Layer thickness – by measurement of core thickness, by level differences, by determining the average for the lot derived from the tonnage placed and the area, as may be specified in the contract specifications;
- Profile - rolling straight edge;
- Marshall properties - one sample per 100 tons with a minimum of six samples per lot per day (except in respect of creep) for assessment of:
    - Aggregate grading;
    - Shape (flakiness and percentage of fractured faces) but only when shape is in doubt;
    - Stability flow;
    - Stability/flow ratio;
    - Voids in mix;
    - Binder content;
    - Dynamic Creep - one sample per 2500 tons, with a minimum of three samples per lot. The frequency of testing is to be increased for gap and semi-gap graded mixes and according to traffic class and sensitivity of mix.

24 BINDER SPRAYING

24.1 General

The binder distributor must be a mobile unit complying with all road traffic regulations and covered by a valid certificate of compliance with TMH2 not more than six months old.

24.2 Testing

Notwithstanding the fact that the distributor must have a certificate of compliance, the following tests must be carried out on site before commencement of spraying work and repeated whenever the RE believes that the spray application results warrant this:

- Spray bar distribution, using the specific product at the correct spraying temperature. Check for spray flares and for blocked nozzles;
- Pan test: This is a hazardous test especially when hot binders are used. Adequate care must be taken to prevent burns. Check the variation in rates of application limits given below:
    - The variation in rate of application between any set of three nozzles shall not exceed 5% and the variation of any set of three nozzles from the mean spray rate for the full bar shall not exceed 5%.
    - If these requirements are not met, the distributor shall not be used until the problems have been rectified.
- A full-scale trial during which the operator shall demonstrate his ability to apply the binder satisfactorily and at the required rate. Where hand-spray work must be done, the methodology to be adopted must be agreed upon. Visual checks shall be made for problems such as streaks and erratic application. Should any such problems be evident or should the spray rate for the trial section fall outside the permitted tolerances, the problems shall be rectified and a new trial carried out.

24.3 Checks to be made before production spraying

The following checks shall be made before every bitumen spray applied to the road:

- The calibration certificate for the distributor is available and valid;
- All items of plant required, including such standby plant as may have been called for by the RE are present and in good working condition;
- No leaks of bitumen, fuel, oil, brake fluid are evident at any item of plant to be used and there is no excessive grease present;
- The spray bar is at the correct height;
- The correct type and number of nozzles are open and fully functional, with fishplates fitted where necessary to achieve the correct spray width;
- The nozzles are set at the correct angle to the spray bar;
- The nozzles are turned to curtail the spray fan where necessary;
- There is a proper overlap of adjoining sprays;
- The indicated road speed has been checked;
- The pump output and road speed have been correctly set;
- The binder temperature is correct and the binder is circulating;
- The tachometer is visible to the operator;
- The guides for the spray edges have been correctly set out using an acceptable type of line;
- The guide bar for the operator is correctly set;
- The spray width does not exceed 4.3 m;
- An impervious sheet has been placed at the start and end of the spray run;
- Air and road temperatures as well as other weather-related constraints are within specified limits;
- Viscosity and softening point are within specification for rubber binder and other modified binders respectively;
- A one-litre sample of the binder has been extracted from the spray bar immediately before the commencement of spraying and sealed in an approved container;
- Adequate traffic control measures are in place where relevant;
- Sufficient trucks loaded with enough aggregate to cover the binder to be sprayed are waiting behind the distributor.

24.4 Reading of dipstick

The dipstick of the distributor shall be read before and after each spray run with the distributor standing on a level section of road. If this is not possible for whatever reason, then the readings shall both be taken with the distributor standing at the same spot.

25 REQUIREMENTS WHEN WORKING WITH SPRAYED BITUMINOUS PRODUCTS

25.1 General remarks

This section deals with some of the important issues common to the utilisation of sprayed bituminous products. The use of tar is generally to be avoided due to its carcinogenic and other undesirable properties.

Stringent weather restrictions are applicable before spraying operations may proceed. These may be found in the standard specifications and include moisture, temperature and wind restrictions. In addition, specified requirements relating to moisture content of the underlying granular base, road surface temperature and bituminous product application temperature must be complied with and recorded, together with the dipstick readings before and after each spray run.

25.2 Health matters

Paragraphs 7.1 and 7.3 of the Environmental Manual set out general requirements relating to health and safety. Working with bitumen products is hazardous, particularly when used hot. The following matters amongst others must be taken into account.

- Extreme care must be exercised when handling binders at high temperatures because accidental contact could result in serious burns.
- Hot penetration or cutback grades of bitumen must never be transferred into storage tanks that contain free water. The high temperature of the binder will cause instant steam and rapid ejection of the hot binder.
- Emulsifying agents, acids and bases which are present in some bitumen emulsions may cause irritation of the skin and eyes and may produce allergic responses.
- Hydrogen sulphide may form in heated bitumen storage tanks. This gas is highly toxic and when concentrations exceed 10 ppm it can be explosive and should be considered hazardous. Care should be taken not to use a naked flame or cause sparks in confined areas such as storage tanks. When work is necessary in confined areas, adequate ventilation must be provided. Anyone entering suspect areas should test for gas concentrations and where necessary, breathing apparatus should be used;
- Protective clothing, goggles of the chemical safety type which exclude air flow and respirators should be made available to personnel;
- Barrier cream should be applied to exposed skin prior to working with bituminous products. It will assist in subsequent cleansing but should never be regarded as a substitute for protective clothing.
- Personnel must be advised of possible irritation they may suffer if the above precautions and protective measures are not followed.

25.3 Storage of emulsions

25.3.1 General

Emulsion is not stable for indefinite periods. It should normally be used as soon as possible after delivery. It should not be subjected to very low temperatures or to great fluctuation in temperature during storage. The following procedures shall be followed if emulsions are to be stored for any length of time.

25.3.2 Drum supplies

Drums must be stacked at a slant and protected from frost. Drums should not be stored for periods longer than three months and should be rolled for a minimum of five revolutions every three weeks. All drums shall be rolled immediately before the contents are used.

25.3.3 Bulk supplies

The emulsion shall be protected from frost and circulated slowly for 30 minutes every 30 days by means of a circulating pump (the bitumen distributor can be used for this purpose if the necessary hoses and couplings are available). This procedure should also be carried out just prior to using emulsion that has been stored for any length of time.

25.4 Rejection of out-of-tolerance binder sprays

25.4.1 Unmodified Bitumen Binder

The following guidelines are to be applied in respect of acceptance or rejection of conventional binder sprays for surface treatments.

The permissible tolerance by which sprays may deviate from that specified is ±0.06 litre/m^2 net cold (20^0C) binder.

Sprays of 0.07 litre/m^2 to 0.10 litre/m^2 above or below that specified shall be rejected, but acceptance thereof at reduced payment (as offered by the Contractor) can be considered. Percentage reductions in the tendered rate for surfacing that are considered to be reasonable are given hereunder for guidance.

AMOUNT BY WHICH SPRAY NET COLD BINDER DEVIATES FROM THAT SPECIFIED (ℓ /m^2)	% OF TENDERED SURFACING RATE TO BE PAID
0.06	100
0.07	95
0.08	90
0.09	85
0.10	80

Table 25-1 : Reduced payment on bitumen spray

When the percentage reduction in the tendered rate is applied, no adjustment in respect of variation from the ordered rate is to be made.

Sprays which are lower than that specified by more than 0.10 l/m^2 are to be rejected. However, the Contractor may propose remedial measures. In this case a remedial measure such as a fog spray may be acceptable.

Sprays that exceed that specified by more than 0.10 l/m^2 shall be rejected outright. The Contractor may submit proposed remedial measures, although in this case there does not appear to be much that can be done other than completely reworking the surfacing. The only exception could be where such excessive application rate occurred in the first spray of a two-spray application (e.g. Cape Seal), or in the first or second spray of a double seal using a third spray (fog spray). An increase or decrease in the bitumen content of the slurry of a Cape Seal is not an acceptable remedial measure. In all cases where the total net cold binder limit (0.10 l/m^2) is exceeded, an extended maintenance period is not acceptable as a solution.

25.5 Precoating

Precoating of the aggregate is mandatory for bitumen-rubber seals. Precoated aggregate must be protected against washing-off of the precoating during rainy weather by temporarily covering the stockpile, which must remain free of moisture. After the rainy weather has cleared, the covering must be removed immediately to facilitate drying of the precoating material. If drying cannot be achieved prior to application due to inclement weather, an asphalt plant may have to be employed to achieve the required level of "dryness".

Because bitumen-rubber used in seals is a proprietary material, the degree of "dryness" of the precoating material needs to be clarified with the specialist supplier/contractor. Different suppliers have different interpretations and this may affect the product warranty.

26 PRIME

26.1 General

It is often thought that prime is impervious. This is not correct in respect of the types of prime and application rates normally used. There are several advantages to applying the surfacing as soon as possible after the prime, especially where carbonation might be an issue in the base.

26.2 Checklist

Check the following as may be relevant and take the appropriate action:

- the base has been tested and approved;
- moisture contents in the base are within specified limits;
- Where required, base corrections have been carried out and approved;
- the base has been lightly broomed and has been properly cleaned;
- water spray has been applied if required;
- the prime in the distributor is the correct material at the correct temperature;
- all pre-spray checks listed in 24.3.

Establish and/or do the following:

- Trial section;
- Quantities or the measurements necessary for the calculation of quantities;
- All administrative work.

Carry out the following tests:

- Prime - compliance with the specification using 1 litre samples both prior to supply and at suitable intervals during the construction process;
- Spray-rate measurement and control.

27 OTTA SEALS

27.1 General

One of the keys to success in the construction of Otta seals is the application of sufficient rolling. On the day of construction, two pneumatic tyred rollers of minimum mass of 12 ton are essential because of their ability to knead the binder upwards into the aggregate particles and to apply pressure over the entire area. A minimum of 15 passes with a pneumatic tyred roller over the entire surface area, including the shoulders, is required on the day of construction.

It is an added advantage to apply one pass of a 10 to 12 ton static tandem steel roller over the entire surface area after the initial rolling has been completed on the day of construction. This improves the density of the structure by breaking down weaker aggregate and can be repeated for the first two days after sealing.

During the next 2 to 3 weeks, aggregate that has become dislodged by traffic should be swept back into the tyre tracks so that maximum aggregate embedment is achieved. After 2 to 3 weeks, the excess aggregate can be swept off. If natural gravel with a high fines contact was used, the period of trafficking and sweeping back of aggregate shall be extended as necessary.

Early trafficking is advantageous for Otta seals, but it is important that the traffic should be directed so as to cover the entire surfaced area uniformly. This can be achieved by directing traffic into designated “lanes" marked with cones or delineators. Heavy traffic should be allowed on the surfaced area immediately following the completion of the initial rolling with pneumatic rollers as this will assist in the kneading of the binder/aggregate mixture. However, a maximum speed limit of 40 km/h should be applied.

27.2 Special Considerations for Double Otta Seals and Combination Seals

It is desirable to spray the full width of the road in one pass. However, if longitudinal joints are necessary, they should be positioned outside the wheel tracks. A minimum longitudinal joint overlap of 150 mm must be maintained and additional heavy rolling must be applied to even out the joints and ridge build-up caused by

bitumen overspray. Transverse joints should never be placed one above another. These joints should be staggered by at least 250 mm.

Curing of the first seal must continue for at least 8 to 12 weeks (depending on curing conditions and binder type) before applying a second seal, so that fattening up due to cutter oil can be minimised.

It is essential when applying sand cover seals that enough cover aggregate is applied and that dislodged aggregate is swept back onto the binder surface.

27.3 Checklists

Check the following as may be relevant and take the appropriate action:

- moisture contents in the base are within specified limits if rain has fallen since the prime was applied;
- base corrections have been carried out and approved;
- the prime has been properly cleaned;
- the binder in the distributor is the correct material at the correct temperature;
- all pre-spray checks listed in 24.3 have been carried out.

Establish and/or do the following:

- Determine the suitability of the aggregate in relation to bitumen adhesion and absorption;
- Quantities or the measurements necessary for the calculation of quantities;
- All administrative work.

Carry out design verification by means of a trial section and the following test:

- Grading – minimum of 5 samples per source

Carry out the following acceptance tests:

- Grading – minimum of 5 samples per source;
- Binder – compliance with specification using 1 litre samples once prior to supply and at suitable intervals during construction;
- Aggregate spread rate – measure to determine compliance with the rate determined during the trial section;
- Sand spread rate – measure to determine compliance with the rate determined during the trial section;
- Spray rate measurement and control.

28 SAND AND GRIT SEALS

28.1 General

Surfacing with sand or grit should be conducted during the hot summer months to achieve maximum benefit from the long hours of sunshine for rapid loss of volatiles. Surfacing operations should be suspended during windy conditions. Even slightly windy conditions produce a cloud of dust from the dry sand or grit which obscures the truck driver's view. This results in an untidy and wavy longitudinal joint. Adjoining lanes shall overlap by 150 mm. If the wind is blowing this requirement cannot be met since part of the overlap gets covered with windblown sand before the adjoining spray can be applied.

If a second seal layer is required, a curing period after application of the first layer of not less than 3.5 months shall be allowed to counter bleeding.

28.2 Checklists

Check the following as may be relevant and take the appropriate action:

- Moisture contents in the base are within specified limits if rain has fallen since the prime was applied;
- Base corrections have been carried out and approved;
- The prime has been properly cleaned;
- The binder in the distributor is the correct material at the correct temperature;
- All pre-spray checks listed in 24.3 have been carried out.

Establish and/or do the following:

- Quantities or the measurements necessary for the calculation of quantities;
- All administrative work.

Carry out design verification by way of a trial section and the following test:

- Grading – 5 samples per source.

Carry out the following acceptance tests:

- Grading – minimum of 5 samples per stockpile up to 150 m^3, thereafter one sample per 30 m3, taken from trucks delivering to stockpile;
- Binder – compliance with specification using 1 litre samples once prior to supply and at suitable intervals during construction;
- Aggregate spread rate – measure to determine compliance with the rate determined during the trial section;
- Sand spread rate – measure to determine compliance with the rate determined during the trial section;
- Spray rate measurement and control.

29 CHIP AND SPRAY SEALS

29.1 General

The construction programme shall take into account as far as possible the temperature and rainfall patterns pertaining to the site. Weather-related limitations as set out in the specifications must be adhered to.

Adequate traffic control is essential, especially during resealing operations, to protect the travelling public, the workmen and the work itself. For seals using emulsions, inadequate traffic control will result in chip loss even when proper quantities of binder and aggregate have been applied. Posted speed limits are generally not an effective means of control. In certain cases a leading pilot vehicle may be required. Because of the beneficial effects that slow-moving traffic can have on the new chip seal, pilot vehicles may be one of the most significant factors in ensuring success of the seal.

Sampling for testing of all aggregates shall be carried out in accordance with SABS 827.

29.2 Remarks Specific to Various Types of Surfacing

29.2.1 Single Application of 6.7mm Stone

A fogspray should be applied if the stone is cubical, to help prevent whip-off.

After completion the road shall be kept closed to traffic for as long as possible. The period of closure will depend on weather conditions and the rate at which the emulsion breaks, but 2 hours is considered the absolute minimum.

29.2.2 9.5mm or 13.2mm Stone plus Sand Blinding

The purpose of the sand blinding is solely to prevent pick-up by traffic. It must be applied as long as possible after the second spray has been applied but not before the emulsion has broken. The application of excess sand must be avoided, but should this occur, the excess must be broomed off before opening to traffic.

The road may be opened to traffic as soon as sand-related operations have been completed.

29.2.3 13.2 or 19.0 mm plus 6.7mm Stone and 13.2mm Plus Grit

The second emulsion spray and 6.7mm or grit aggregate as the case may be, shall be applied to the full primed width of the base. This process may only commence after the emulsion of the first spray has fully broken and the 13.2 or 19.0mm chipping operation has been fully completed but not less than twelve hours after the first spray.

The fogspray shall be applied not less than twelve hours after application of the second spray.

The road may be opened to traffic after the fogspray has broken completely.

29.2.4 19.0mm Stone plus Slurry (Cape Seal)

Where emulsion is used for the first spray it shall be free of any fluxing agents. Winter grade emulsions in particular can contain significant quantities of fluxing agents which are trapped in the seal by early slurrying. This results in fattiness and bleeding of the seal.

29.2.5 19.0mm Stone plus Hot-mix asphalt (Modified Cape Seal)

This seal is slightly more labour-intensive than the Cape Seal, but require more equipment to heat the crusher sand.

Apart from consistency in mix ratios, workability of the asphalt mix, even distribution of the mix by hand and avoidance of uneven initial compaction are essential for a good finish with good riding quality. More in-depth training of the labour force is necessary before commencement, since spreading without any practical measurable tolerance in the field makes this art rather than skill. Skids welded below a heavy channel for initial spreading will contribute to smooth spreading of the asphalt.

The mix ratio and colour of the seal is often more consistent than in the case of a standard Cape Seal.

29.2.6 13.2mm Bitumen-Rubber Seal as Reseal

Any major cracks and failures shall be repaired as specified in the project documents. Overfilling of cracks with sealant must be avoided. The moisture content in the underlying base must be checked and measures taken to avoid trapping excessive moisture in that layer.

After completion of the blending operation, for storage, the binder shall be cooled to between 150^{O}C and 175^{O}C (refer to COLTO). The binder mixture may only be stored in tanks with circulation systems and may not be stored for more than two days. The maximum holding time for binder at spraying temperature shall be four hours and the maximum storage temperature shall be 35^{O}C below spraying temperature. Refer to COLTO for spraying temperatures.

Where a bitumen-rubber seal is applied as an inter-layer membrane to an asphalt overlay, an additional curing time of at least 48 hours is required to ensure that diluents have evaporated sufficiently to prevent softening of the asphalt.

29.2.7 Checklists

Check the following as may be relevant and take the appropriate action:

- As for Otta seal;
- All specified lag times between operations have been allowed;
- All rolling requirements have been met;
- Requirements before opening to traffic have been met;
- Temperature constraints have been complied with.

Establish and/or do the following:

- Quantities or the measurements necessary for the calculation of quantities;
- All administrative work.

Carry out design verification by means of a trial section and the following tests:

- Grading including fines and dust content – 1 sample per 30 m^3 with a minimum of 5 samples per stockpile;
- Aggregate ALD and flakiness – as for grading;
- Bitumen adhesion – as for grading;
- Efficiency of precoating or wetting agent – see Project Specifications.

Carry out the following acceptance tests:

- Aggregate strength (hardness), durability, flakiness, grading, fines content, dust content – 5 samples for each aggregate size before commencement and at suitable intervals throughout construction;
- Binder – compliance with specification once prior to commencement;
- Water – compatibility for dilution (and in the case of cationic emulsions, also organic impurities) once per source prior to construction and thereafter as necessitated by weather conditions and potential seasonal variations;
- Aggregate spread rate – measure each lot to determine compliance with the rate determined during the trial section;
- Sand spread rate – measure each lot to determine compliance with the rate determined during the trial section;
- Spray rate measurement and control for each lot.
- Binder during production – viscosity:1 test per batch delivered:
    - penetration grade: 1 per work day;
    - softening point: 1 per work day;
- Emulsion during production – binder content:1 per batch:
    - viscosity: 1 per work day;
    - softening point: 1 per work day.

30 SLURRY FOR SEALS

30.1 Slurry for Cape Seals

Extended curing times may be necessary at intersections and accesses, especially where the road is used by heavy vehicles.

30.2 Conventional, slow-setting anionic coarse slurry (CSSACS) and rapid setting, rubber modified coarse slurry (RSRMCS)

One or more trial sections shall be made using the approved mix before any coarse slurry is placed on the road. The trial mixes shall be used to determine the most suitable stage at which to provide initial compaction with a pneumatic roller and/or to allow traffic onto the layer. Timing shall be related to physical observations as well as permeability results obtained with a Marvil apparatus on cured material.

Rolling shall proceed from the haunch, kerb or channel and shall lap in half-widths while working to the crown or upper end of the crossfall or superelevation of the road. The layer should not show significant displacement under the rollers. Shaded areas and/or thick layers should be checked for wet patches. Rollers should not be permitted to stand on newly-laid coarse slurry until it is fully compacted and has set completely.

For CSSACS the design and compaction shall provide an in situ seal with a mean permeability not exceeding 1.0 l/hr measured in accordance with the Marvil method and based on a minimum of six tests per lot. A maximum permeability of 4 l/hr for individual values will be tolerated within a lot comprising six tests.

For RSRMCS the design and compaction shall provide an in situ seal with a permeability not exceeding 0.5 l/hr measured in accordance with the Marvil method.

When more than one layer of coarse slurry is laid, the transverse and longitudinal joints in a subsequent layer shall be staggered by at least 0.15 m from the joints in the lower layer.

30.3 Checklists

Check the following as may be relevant and take the appropriate action:

- Moisture content of underlying layer;
- Crusher dust comes from an approved stone source;
- Approved design of slurry has been used;
- Correct rolling pattern has been used;
- Weather constraints have been met;
- Batch proportions are correct.

Establish and/or do the following:

- Calibrate the mass measuring device;
- Quantities or the measurements necessary for the calculation of quantities;
- All administrative work.

Carry out design verification by means of a trial section and the following tests:

- Aggregate grading, also of sand/crusher dust blend if used – 5 samples per source;
- Consistency - refer to Project Specifications for flow requirements.

Carry out the following acceptance tests:

- Emulsion viscosity – 1 sample per delivered batch;
- Grading and binder content of slurry mix – 1 sample per 50m^3 of mix with a minimum of 5 samples per day. Test all samples on the first day to check conformance with specification, thereafter one sample daily on a random basis. Remaining samples may be discarded after 2 months if permeability is acceptable and the actual bitumen content correlates with daily mix ratios, and there are no visible surface defects;
- Workability of slurry mix – 1flow test per 5m3 batch;
- Spread rate – coverage in kg/m^2 per batch;
- Permeability – minimum of 6 Marvil tests per km

31 ASPHALT SURFACING

31.1 General

This section covers hot-mix asphalt surfacing using unmodified and modified bitumen for binders. The proposed mix design shall be submitted to the control laboratory:

- eight weeks before commencement of asphalt construction for quality approval and mix design;
- two weeks before construction for quality approval only, or for amendments to an existing design.

In-place densities of the compacted layer shall be determined in a stratified random manner. Bridge decks are to be treated as a separate lot for determination of density. The frequency of sampling on bridge decks shall be increased because of greater variability in asphalt thickness.

The thickness of the layer as well as the temperature of the mix shall be continuously checked. The average thickness paved must also be checked on a daily basis and compared with the nominal thickness. Any significant variations must be immediately investigated.

Control of aggregates from both stockpiles and hot bins shall be exercised.

31.2 Aggregates

31.2.1 Aggregates in stockpiles

Stockpile quality assurance control shall apply to the manufacturer of the asphalt and to the supplier of the aggregate. Representative samples for testing shall preferably be taken from the trucks, or from the dumped heaps, per layer according to SANS 827. The frequency of sampling shall be approximately one per 400m3.

All the samples shall be tested for grading and shape. Variability shall be statistically assessed. The aggregate should also be tested for hardness, relative density and bitumen absorption. The material from the stockpiles shall:

- conform to the specifications, and
- be sufficiently uniform to consistently produce the mix design.

Heaps shall only be flattened after the test results have been assessed for compliance and found to be acceptable.

31.2.2 Aggregates in hot bins

Control of the grading of hot bin material shall be exercised by the asphalt supplier.

Hot bin samples shall be obtained by emptying the contents of a particular hot bin into a truck and the samples taken from the asphalt in the truck. Frequency of sampling shall be one sample per bin per 400 tons of mixed material but not less than one per day.

If the grading of the materials being mixed is outside the job mix design limits (as verified in the trial section), the work shall be stopped until the matter has been rectified. It is thus important to get test results as soon as possible. Results should be available within 24 hours.

31.3 Checklists

Check the following as may be relevant and take the appropriate action:

- Test results on aggregates from both stockpiles and hot bins;
- That sufficient “hot boxes” are available at the point of laying to transport the test samples from the day’s production to the laboratory;
- That the temperature (including road temperature) and moisture conditions are suitable for the laying of asphalt;
- That all necessary equipment is present and in working order, attention being paid to screed head, screed crowning, screed and tamper wear, auger feed controls, etc;
- That the tack coat has been applied, has broken and is clean;
- That the edges of previously laid asphalt against which the day’s production will commence have been properly prepared;
- That edge controls are present and correct with functioning sensors;
- That adequate traffic control measures are in place;
- That the moisture content of the underlying base is within the specified limits;

- That preliminary actions such as heating of the screed bar of the paver have been taken;
- That asphalt delivery trucks are fitted with appropriate load covers;
- That the asphalt in each truck upon arrival shows no signs of having been overheated, is at an acceptable temperature and is correctly tipped into the hopper, or loaded via a material transfer vehicle (MTV);
- That the cycle time of trucks is credible, especially for loads that have been rejected.

- That the mix design has been approved by the RA's Control Laboratory;

Establish and/or do the following:

- That the mass measuring equipment at the asphalt plant has been calibrated and the calibration certificate is still valid;
- As many trial sections as may be necessary.
- Record all salient information that may be needed to evaluate performance and to determine the cause of possible failures or deviations from the expected results. This will include but will not be limited to:
    - details of weather conditions
    - road temperature
    - moisture regime in underlying base
    - details of equipment used
    - construction procedures
    - temperature of asphalt in arriving trucks and on placing
    - delays to the laying process
- Positions of sample points.
- Quantities or the measurements necessary for the calculation of quantities;
- All administrative work.

Carry out design verification:

Approval of the proposed mix design by the control laboratory does not constitute final approval of the job mix. The job mix requirements shall be verified by means of a trial section. As the project progresses the mix might alter.

Provided that all the test results are satisfactory the design mix may be amended subject to the approval of the Senior Materials Engineer.

The following tests shall be carried out on each trial section and the results reported to the control laboratory:

- Aggregate grading, shape and Marshall Design – 6 samples from behind the paver;
- Dynamic Creep – 3 x 100 mm dia. cores;
- Tensile properties (eg ITS) – refer to Project Specification;
- Density – minimum of 6 x 100 mm dia. cores;
- Permeability – minimum of 6 samples;
- Levels and thicknesses.

Carry out the following acceptance tests:

- Aggregate supply – strength, durability, shape: 1 sample per 7500m^3.
- Aggregate/asphalt – grading, shape, binder content, Marshall properties: 1 sample per 100 ton with a minimum of 6 samples per lot per day, dynamic creep 1 per 2500 ton with a minimum of 3 samples;
- Filler supply – grading, fines content, dust content: 1 sample per 7500m^3;
- Bitumen – compliance with specification: 1 sample per 500 tons of asphalt;
- Temperature - mixing and supply temperature controls: minimum of 1 temperature reading per load;
- Temperature – supplied asphalt: minimum of 1 reading per load just before tipping into the hopper and 1 per load immediately before breakdown rolling;
- Density – 1 per 100 ton with a minimum of 6 x 100mm dia. core samples per lot (minimum of 8 on bridge decks);
- Permeability – testing frequency as for density;
- Laid asphalt mat – complying cross-fall, thickness and level, with no shearing, ridges, segregation or irregularities on surface, conforming to riding quality.

NOTE: The foregoing check lists relate to asphalt constructed with unmodified bitumen binder. If a modified binder such as bitumen rubber is used, some of the requirements will change. In such cases, refer to the Project Specifications for the necessary information.

32 CONCRETE STRUCTURES

32.1 General

Concrete is an unforgiving material. Once in place and hardened, it is an expensive exercise to rectify defects. Accordingly, it is of the utmost importance that the Contractor exercises skill and care in the process of creating a concrete structure. It is equally important that the RE and his staff apply their minds to the checking of all processes associated with concrete structures. Attention to detail is paramount.

There is nothing more pleasing than a properly designed structure which has been constructed with care. On the other hand, some structures which have been designed with world-class architectural and engineering input - for instance on the Costa del Sol in Italy - which have been ruined to the discerning eye by careless construction and poor finishing.

32.2 Foundations

Check the following as may be relevant and take the appropriate action:

- Setting out;
- Access and drainage;
- Lateral support or slope stability;
- Safety measures including control of an authorised access and in respect of blasting;
- Coffer dam design;
- Overbreak in hard material
- Over-excavation/foundation fill;
- Foundation dowels;
- Acceptability of founding conditions and material;
- Backfill
- Measurement for quantities.

32.3 Piling

Check the following as may be relevant and take the appropriate action:

- Approval of the Contractor's alternative design;
- Setting out;
- Safety measures including control of unauthorised access and use of a piling platform;
- Type and size of pile;
- Reinforcement;
- Embedded tubes;
- Fittings e.g. rock shoe, casings;
- Installation-position, inclination, top and bottom levels;
- Founding process (bulbous base, under-ream, rock socket);
- Piling records (driving effort, resistance to penetration at founding level, rate of penetration including through obstructions, heave after 24 hours, set after re-driving, depth to groundwater, depth of rock socket);
- Pile testing (core drilling, load test, integrity test).

32.4 Reinforcement and prestressing steel

Check the following as may be relevant and take the appropriate action:

32.4.1 General

- Storage of reinforcement and prestressing steel from delivery until placing;
- Reinforcing and prestressing steel comply with specifications;
- Condition of reinforcement and prestressing steel (e.g. scale, rust, mechanical damage);
- Bending and cutting correctly executed.

32.4.2 Placing and fixing

- Type (R or Y), diameter and bar mark;
- Number and spacing, alternation of laps, clearances;
- Adequacy of fixing ties, spacers and blocks, stools;
- Adequacy of fixing and support of starter bars and other inserts;
- Minimum and maximum cover as per drawing/specifications;
- Cleanliness of reinforcement;
- Installation of couplers;
- Welding procedures and welds if approved;
- Approval of prestressing system and Contractor's detailed prestressing drawings;
- Line and level of prestressing ducts;

- Support, fixing and sealing of prestressing ducts;
- Type, diameter, number of elements of prestressing steel;
- Type, angle and position of anchors;
- Number, diameter, length and installation of vent pipes;
- Position and arrangement of bursting reinforcement.

32.5 Falsework and formwork

Check the following as may be relevant and take the appropriate action:

32.5.1 Falsework

- Bearing capacity of ground under the bearers-bearing in mind wet/dry support conditions;
- Drainage of platform;
- Approval of falsework design;
- Safety measures for workforce;
- Adequacy of bearers;
- Stability of base and top jacks;
- Bracing of supports;
- Main and cross girders/bearers;
- Presence and nailing of wedges;
- Line, level and position;
- Safe access for construction traffic;
- Safe clearances for public traffic including height and width gauges;
- Barriers protecting falsework from traffic impact.

32.5.2 Formwork

- Setting out, dimensions and precamber;
- Safety measures for workforce;
- Condition of formwork;
- Cleanliness of box;
- Line and level of chamfers
- Sealing of formwork;
- Ferrules, ties and cones;
- Walers;
- Contraction and construction joints.

32.5.3 Permanent formwork

- Type, support and tie-down;
- Bracing, drainage and prevention of flotation of circular void formers.

32.6 Precasting yard

- Quality system in place;
- Approval of concrete mix design;
- Accuracy and rigidity of formwork;
- Approval of concrete compaction system;
- Control of cover;
- Approval of procedure and timing for removal of formwork;
- Approval of lifting method and lifting points;
- Approval of transport and storage system.

32.7 Concrete

Check the following as may be relevant and take the appropriate action:

32.7.1 Mix design

- Component compliance-water, cement, sand, stone (including durability), additives.
- Alkali-aggregate reaction;
- Approval of mix design;
- Mix proportions, slump, bleeding and cube strength.

32.7.2 Pre-concreting

- Falsework, formwork, reinforcement, prestressing elements, cover;
- Installation of additional components (drip grooves, drainpipes, bolt groups etc.);
- Preparation of construction joints;
- Kicker formwork in place and secured;
- Sufficiency of concrete components at hand and ready for use;
- Batching plant, transport system, placing system and ancillary equipment adequate and fully operational;
- Lighting available for night work;
- Sufficient cube moulds and slump cone ready for use;
- Covering for completed cubes ready for use.

32.7.3 Concreting

- Accuracy of batching;
- Placing and compaction;
- Re-vibration;
- Finishing of top surface;
- Application of approved curing system;
- Taking of cubes and slump measurements.

32.7.4 Post-concreting

- Continuation of approved curing system for required duration;
- Minimum stripping times for formwork and falsework;
- Prestressing tendons free to move;
- Prestressing ducts and grouting vents flushed;
- Honeycombing repaired;
- Fins removed and other repairs made; F1, F2, and F3 finishes achieved as specified.

32.8 Prestressing

- Ducts flushed all and tendons freed after concreting;
- Approval of the load cell readings and extensions;
- Approval of prestressing programme;
- Structure is free to shorten under prestress;
- Removal of temporary fixity of bearings;
- Compliance with concrete strength required before stressing;
- Prestressing and grouting equipment complies with specifications and has been calibrated;
- Approval of grout;
- Prestressing and grouting records.

32.9 Bridge expansion joints

32.9.1 Compliance with specifications

- Materials qualities and corrosion protection;
- Test certificates and warranties;
- Supplier Agrément accreditation;
- Approval of supplier's drawings: type, size, geometry, movement, capacity etc.

32.9.2 Installation

- Measurement of joint housing;
- Fixing in place: alignment, levels, rigidity, joint gap;
- Concreting in place;
- Water tightness test;
- Release of temporary fixing;
- Cleaning of joint gap.

32.10 Bridge bearings

32.10.1 Compliance with specifications

- Materials qualities and corrosion protection;
- Test certificates and warranties;
- Supplier Agrément accreditation;
- Approval of supplier's drawings: type, size, load capacity, preset etc;
- Adapter plates;
- Compression and shear test results of elastomeric bearings;
- Adequacy of space for bearings and adapter plates.

32.10.2 Installation

- Positioning: alignment, level, preset, rigidity of supports and straps;
- Grouting of anchor bolts and bearing bedding;
- Chock supports for precast beam decks;
- Removal of bearing restraints;
- Cleaning of bearing seat.