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Proceedings of Four Country Workshops in Southern Africa: Outcomes and Indicative Actions

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by C S Gourley and P A K Greening

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PROCEEDINGS OF FOUR COUNTRY WORKSHOPS IN SOUTHERN AFRICA:

Outcomes and Indicative Actions

Contents

ABREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
BS	British Standard
CAS	Central African Standards
CRL	Central Roads Laboratory
CBR	California Bearing Ratio
CSIR	Council for Scientific and Industrial Research
DCP	Dynamic Cone Penetrometer
DFID	Department for International Development
DMR	Departmental Materials Reports
Esa	Equivalent standard axle
GIS	Geographical Information System
GPS	Geographical Positioning System
ICC	Initial Consumption of Cement
ICL	Initial Consumption of Lime
IT	Information Technology
LVR	Low Volume Road
MoTE	Ministry of Transport and Energy
NORAD	Norwegian Agency for Development Co-operation
NPRA	National Provincial Road Authority
PMS	Pavement Management System
OMC	Optimum moisture content
ORN	Overseas road note
RDC	Rural District Council
RDB	Road Data Bank
SADC	Southern African Development Community
SATCC	Southern African Transport and Communications Commission
SIDA	Swedish International Development Agency
TRH	Technical Recommendations for Highways
TRL	Transport Research Laboratory
TTC	Texas Triaxial Class
UCS	Unconfined Compressive Strength

1. Introduction

The Transport Research Laboratory (TRL) has recently completed a Technology Development and Research project for the Department of International Development (DFID) entitled "Highway Engineering Materials in Southern Africa". The Swedish International Development Agency (SIDA) and from the Norwegian Development Agency (NORAD) provided additional funding for the project.

The project comprised the following four components:

- Natural gravels for road construction
- Chemically stabilised roadbase materials
- Development of a computerised materials inventory
- The environmental impact of borrow-pit extraction.

Prior to finalisation of the technical reports for each of the four components, the findings of the project were presented in a series of workshops in the four collaborating countries (Botswana, Malawi, Zambia and Zimbabwe) for discussion and feedback. This report summarises the outcome of the workshops held in Zambia (2 – 4 March 1999), Botswana (10 – 11 March 1999), Malawi (16 – 18 March 1999) and Zimbabwe (24 – 25 March 1999).

In addition to the four components of the workshop, feedback was also given on the revised calcrete specifications emanating from a previous project to evaluate the performance of test sections in Botswana.

2. Workshop structure

The workshops were structured to allow for maximum participation and feedback from the delegates through a series of facilitated tasks, presentations of the project findings and facilitated discussion sessions. The following questions were posed to the delegates for feedback:

Natural Gravels

Task 1 - What are the main causes of deterioration of low volume roads?
Task 2 - What are the problems with the current pavement design approaches?
Task 3 - What are the perceived risks in reducing standards for low volume roads?

Chemical Stabilisation

Task 1 - What are the advantages and disadvantages of lime and cement stabilisation?

Materials Inventory

Task 1 - How could a materials inventory be used?

Environmental Impact of Materials Extraction

Task 1 - What are the environmental problems created by materials extraction?

3. Summary of discussions

The feedback from the workshops has been combined under the four components of the project to allow for ease of comparison of similarities and variations of opinion in the different countries.

3.1 Natural gravels for road construction

Most of the work in the research programme was carried out on the project designed to investigate the performance of roadbase materials, which are considered to be "sub-standard" and much of the discussion at the workshop was devoted to the results of this project.

3.1.1 Test methods

The applicability of current tests to materials selection and pavement design was discussed at the workshops as this has important implications for the selection and performance of pavement materials. The calcrete research in Botswana was presented as a further example of research which indicated that the current specifications for natural (as-dug) gravel roadbases were inappropriately high for most of the new roads currently being constructed or planned in the region. This led to an examination by the research team of the origin of the current designs and the test methods used to approve materials with the following observations:

- The Californian Bearing Ratio (CBR) test is the standard fine-grained soil test for the approval of road-base materials. It is a test designed for homogenous sub-grade soils, not highly granular road-base material. Attempts to modify the test for granular soils have led to a number of different practices in conducting the test, thus explaining the poor repeatability and reproducibility of CBR test results.

- The test was designed as an indicator test for soils. It is not a performance-related test. This explains the frequent anomalous behaviour of road pavements constructed with materials with low CBR.

- The test is carried out in the soaked conditions intended to typify sub-grade conditions for much of the year in many parts of Europe and other countries in the northern hemisphere. Sub-grade conditions are often much drier for much of the year in southern Africa.

- The same (soaked) condition is used for design, not only for the subgrade, but for the sub base and even the base, in which moisture conditions in the region are rarely above optimum.

- Although the test is used as an indicator test for material selection, materials ranked in the soaked condition do not necessarily rank in the same order at the moisture contents prevalent in the road pavement.

Many practitioners in the road construction industry now believe that the CBR test should be replaced by a test more likely to represent the performance of pavement materials under traffic. Although such tests exist (e.g. Texas Triaxial test), they are often slower to carry out and need more careful evaluation. It is, therefore, generally accepted that the industry is unlikely to re-invest in the new laboratory equipment required to carry out these tests. The limitations of the CBR test were discussed and recognised at the workshop but the designs and specifications resulting from this research are in the context of existing design philosophy and test methods.

3.1.2 Causes of deterioration of low volume roads

Table 3-1 summarises the perceived deterioration effects for low volume roads.

The following comments were also received during the sessions:

- At the workshops, concern was raised about the definition of a low volume road. This will need attention in the final report to ensure that practitioners are clear on the types of roads being referred to by the revised specifications and designs.
- The influence and nature of the traffic using low volume roads needs to be considered, as often it may not be the over-riding cause of deterioration.
- The over riding cause of deterioration was generally thought to be water ingress and poor drainage. Provided pavement materials (especially the base) could be kept dry many other currently non-standard materials could be used. This also assumes that there is a good maintenance regime for retaining the integrity of the surface seal.
- The appropriate relaxation in material standards should be associated with a clear understanding of the road environment. This should include recognition of the importance of good construction, maintenance and the adoption of appropriate materials, pavement and geometric design standards.
- Sealed shoulders were accepted as an essential measure to improve the performance of non-standard materials and to ensure water doesn’t enter the pavement, especially the area under the outer wheel-tracks.
- Increased use of fog sprays should be considered as a measure to enrich the binder and retain the waterproofing effects of the seal at a relatively low cost.
- The use of graded (Otta) seals should be considered for low volume roads to reduce costs of stone aggregate.

Table 3-1 Perceived causes of deterioration of low volume roads

Common causes	**Country-specific comments**			
	Zambia	**Botswana**	**Malawi**	**Zimbabwe**
Poor drainage	• Flood water scour • Poor drainage structures • Inadequate drainage maintenance	• Water ingress • Maintenance of drainage structures	• Water ingress • Inadequate drainage maintenance • Poor geometric design	• Water ingress • Poor roadside drainage • Sub-soil moisture variation
Inadequate maintenance	• Integrity of the seal • Maintenance culture • Poor maintenance techniques	• Late or no maintenance • Insufficient maintenance	• Integrity of seal • Poor maintenance techniques • Vegetation on shoulders	• Lack of maintenance • Delayed reseal • Unsealed cracks • Poor standard of repair • Edge erosion
Overloading	•	• Associated with high tyre pressures • Unexpected heavy loads after design	• Over-loading	• Over-loading • Heavy traffic
Quality of construction	• Inadequate compaction	• Inadequate compaction • Poor workmanship • Inadequate use of appropriate plant • Poor mixing of materials	• Poor supervision	• Poor construction standards • Permeable pavements • Poor compaction
Materials quality	• High fines content • Non-availability of natural gravels • Packing behaviour of materials	• Low quality of surfacings • Salt damage	• Type of materials used	• Inadequate classification of materials • Poor subgrade materials • Sodic, dispersive and other problem soils
Environmental extremes	No additional comments	• No additional comments	• Weather • Temperature extremes	• Erosion of shoulders and side-slopes • Moisture movements • Weather
Design	• Inadequate camber	• Lack of sealed shoulders • Flat terrain	• Inadequate design specifications • Low embankments • Substandard pavement design • Poor shoulder design	• Under-design • Inadequate pavement design • Increased generated traffic
Others	•		• Lack of resources	• Traffic on shoulders • Age of pavement • Loss of surfacing stone

3.1.3 Problems with current design approaches for sealed low volume roads

Comments on the on the problems with the current design approaches for low volume paved roads are given in Table 3-2. The presentation of the proposed specifications and design catalogues stimulated the following additional comments:

- There was no incentive to consultants to relax designs for low volume roads where appropriate.
- There was a suggestion that the design approaches should be harmonised with the local maintenance capability.
- National standards for low volume roads should be developed in each country.
- The use of the terminology "appropriate standards" should be encouraged to allay the negative perception of inferior standards.
- Current standards do not promote the use of appropriate materials in the pavement layers. They are often prescriptive and rigid in their approach.
- The recommended designs would need further consideration in terms of fine-tuning for adaptation to national standards. However the general feeling was that the research provided valuable inputs towards increasing the confidence of designers and clients in the use of more appropriate, cost-effective designs incorporating materials previously considered to be unsuitable.
- With the exception of the Zimbabwe Road Design Manual the current design guides (ORN31, TRH4, and SATCC) do not cover low volume roads.
- Local design documents and standards are infrequently updated.
- Any move toward adopting more appropriate designs should include a re-evaluation of geometric and other standards which are considered to be too rigid for low-volume roads.
- The increasing use of labour-based methods is likely to involve a lowering of standards in line with those presented. An appropriate weatherproof surfacing which is well maintained will enhance the performance of these roads.
- Consideration should be given to the effect of high tyre pressure on the recommended designs.
- Inappropriate traffic forecasting and the use of unrealistic growth factors was highlighted as a major problem in trying to develop more appropriate design approaches for low volume roads.
- Test methods, in terms of their appropriateness and standardisation (BS, ASTM, TMH1, Central African) became a major issue of debate, especially in Botswana.
- There was a consensus that the CBR test is not appropriate for the strength classification of granular materials, but the investment in the testing equipment throughout the region means that this test is likely to be used as the definitive test for the foreseeable future.
- There was a clear need for better information on the design approaches used (including adequate identification) and treatments to be developed for problem soils. These include dispersive or sodic soils, expansive soils, collapsing soils etc.
- Sealed shoulders should be encouraged and can often be justified by whole-life maintenance benefits alone.

Table 3-2 Problems with current design approaches

	Country-specific comments			
Common problems	**Zambia**	**Botswana**	**Malawi**	**Zimbabwe**
General comments	• No leeway to design outside the specifications • Design focused on main trunk road network • Not adapted to local conditions and experience • Too general; no consideration of the uniqueness of the region	• Rigid • Too closely following high volume approaches • Based on standards that do not reflect local conditions • May not be cost effective	• Minimum thickness of layers is not considered • Written for trunk road network • Not appropriate to local climate or conditions • Rigid and alien • No standards for mountainous roads • No standards for maintenance • Designs are dictated by money available • Maintenance programme should be an important part of the design • Specifications old and out of date, circa 1978	• Design documents old and out of date • No intermediate design class between 0.3 and 1.0M esa • Subgrade design only goes to SG9 • Design speed too low • Curve radii not compatible with speed • LVR's are over-designed • Does not include labour-based approaches • Not easy to update • Infrequent reviews, last one circa 1983
Traffic		• No specific design policy for low volume paved roads	• Traffic forecasts are often too high	• Design traffic limited to 3.0M esa • Low volume criteria not defined • Traffic forecasting, volumes and trends unreliable • National equivalence factor not appropriate for LVR's

/continued

	Country-specific comments			
Common problems	**Zambia**	**Botswana**	**Malawi**	**Zimbabwe**
Materials Design	• Relaxation of material standards not well understood • Availability of adequate materials to meet design standards	• Give little guidance to designers to promote the use of non-standard materials • Surfacing aggregate strength specs too high • Bitumen durability not covered • Strength not specified in fundamental engineering properties	• Local understanding of materials is not addressed	• No surfacing design provided • No tests for sodic soils • Expansive soil identification and treatment needs revised • No harmonisation of test specifications and standards
Inadequate drainage considerations			• Special drainage designs are needed in flat areas • Trench or boxed-in pavement design common	• Low crown heights used • Drainage design too brief and lacking in detail • Environmental issues such as cut slopes not addressed
Insufficient human resources with appropriate training		• Inappropriate experience with the use of marginal materials		• Awareness
Insufficient research into appropriate designs	• Lack of dissemination of research results • Most designs are empirical not analytical • Lack of management of field data	• Designs not verified through mechanistic/ analytical methods • Use of empirical measurements such as CBR		• Need for TTC-CBR correlation

3.1.4 Designs and specifications

In the discussions on the revised design, it was also clear that many participants seemed to be unaware of the origins of "local" designs and specifications. Apart from Zimbabwe, South Africa, and to some extent in Botswana, the documentation in use in many countries in the region has changed little in substance since the pre-independence era. The revisions made in some countries have given little recognition to the considerable research carried out in the region, most of which had the main objective of deriving specifications and standards appropriate for local conditions. Therefore, current documents still primarily reflect designs for conditions of climate, materials and traffic imported from elsewhere.

At the workshops the applicability of current designs and need for revision was discussed at some length. The TRL research team presented the project objectives and the methodology, whereby the performance of test sections, which were representative of much longer sections of the road network, were evaluated. The process of the selection of test sections was explained. These were sections on the existing networks many on trunk roads, which had been constructed with sub-standard materials and had experienced considerable overloading. Some had received little or no maintenance (or reseal) during their life, which in some cases was in excess of 20 years. The good performance of most of these sections under adverse conditions again demonstrated the need for more appropriate designs and materials specifications for low volume roads. The revised designs and specifications presented at the workshops were derived from the analysis of data from the test sections.

Representatives of consultants and contractors as well as most representatives of road authorities, were overwhelmingly in favour of the new designs, specifications and practices presented.

A few representatives of the Roads Authorities, particularly in Botswana, were more reluctant to accept the revised recommendations. The view represented by this smaller group seemed to indicate that some engineers in client road authorities prefer to retain a very conservative approach to road provision, which can result in costly over design of low volume roads.

The overwhelming recommendation by all the participants was that any new recommendations for designs, specifications and work practices MUST be incorporated into country and regional documentation. Only in this way, will alternative and innovative solutions be accepted and gain legitimacy with the authorities responsible for road provision.

3.1.5 Risks

Some of the perceived risks of developing more appropriate standards for low volume roads were identified as:

- Premature road failures
- Lack of performance
- Low life span of road
- Higher cost of maintenance and increased need for maintenance interventions
- Increased dependence on construction quality
- Less margin for error

- No one willing to accept responsibility if designs are not specified in documents, including design engineers and clients
- General reluctance by individuals to change
- Current environment is not conducive to change
- Safety
- More accidents

However, the general feeling was that, should the roads be timeously maintained, the risk of deterioration and failure would be greatly reduced. It was also felt that currently, all the risk was borne by the client and, should more appropriate, relaxed, designs be considered, some form of risk sharing should be developed.

3.1.6 Overall conclusions and feedback on natural gravels project

- The development of appropriate standards and guidelines for the use of materials, currently considered to be unsuitable, was welcomed for low volume sealed roads (i.e. roads not included in the regional trunk road classification).
- Emphasis should be placed on keeping the materials dry. This can be achieved by using appropriately designed seals (incorporating a sealed shoulder if necessary), which are well maintained and have adequate drainage provision.
- The respective Roads Departments should take responsibility for the incorporation of the recommended specifications and design catalogue into documentation and practice.
- The perceived risk of introducing the standards proposed was a major issue, which needs careful consideration before the recommendations are likely to be implemented.

3.2 Chemical stabilisation

The chemical stabilisation project was aimed at examining current practice, particularly in the context of carbonation, which has discouraged some practitioners from using this method of improving the engineering characteristics of soils and gravels. Roadbases in Zambia and Zimbabwe, which had been chemically stabilised with cement or lime were tested to determine if they had carbonated and the residual strengths measured both in the field and on samples tested in the laboratory.

Tables 3-3 and 3-4 summarise the advantages and disadvantages of chemical stabilisation identified by the workshops participants.

Table 3-3 Advantages of Chemical Stabilisation

Common advantages	**Country-specific comments**			
	Zambia	**Botswana**	**Malawi**	**Zimbabwe**
Improved material properties, especially strength and durability	• Good long term performance • Higher bearing capacity • High compaction densities achieved in a short time	• Good long term performance • Materials improvement • High bearing capacity	• Reduced plasticity and increased strength • High bearing capacity	• More predictable behaviour • Reduced pavement thickness requirements • Improves quality, strength, stiffness and bearing capacity
Provides an intermediate cost option	• No additional comments	• Reduced haulage costs	• Cost effective and economical • Cheaper than CSB • Reduced haulage costs	• Reduced quantities of gravels required • Cheaper than CSB and bituminous stabilisation
Allows the use of a wider range of materials	• Allows the use of an increased range of materials	• Allow the use of otherwise unsuitable materials	• Conserves material resources • Can use poor materials	• Enables use of marginal materials • Better use of material resources
Reduces potential for failure	• Unsealed stabilised shoulders less prone to erosion • Rate of pothole formation reduced	• No additional comments	• No additional comments	• Higher road standards achieved • Reduced maintenance costs • More predictable long term behaviour
Other benefits	• Good market for local lime and cement industry • Flexibility in duration of processing (lime)	• Could be labour intensive • Good in wet areas	• Promotes local industry	• Ease of construction • Economic benefits for suppliers • Reduced haulage costs

Table 3-4 Disadvantages of Chemical Stabilisation

Common Disadvantages	Other comments			
	Zambia	**Botswana**	**Malawi**	**Zimbabwe**
Shrinkage and block cracking	• Shrinkage and block cracking	• Shrinkage and block cracking	• Cracks	• Cracking • Increased maintenance costs
Higher costs	• Higher costs for construction and maintenance	• Foreign exchange for import of stabiliser	• Higher costs for construction and maintenance	• Foreign exchange required • Cost of construction prohibitive • Causes maintenance problems
Potential to carbonate with detrimental effects	• Deterioration with time (lime)	• Durability requirements not adequately specified • Loss of strength with time • Carbonation of lime with clatters	• No additional comments	• No additional comments
Cementing process not clearly understood	• Lime susceptible to acid environments	• Effect of deleterious materials • One type of stabiliser not suitable for all materials • Susceptible to attack from soil chemicals and soluble sulphates	• Time required to cure properly	• No additional comments
Increased expertise and quality control needed during construction	• Short setting time for cement stabilisation • Difficult to handle for untrained personnel • Higher standards of construction and supervision needed • Specialised equipment required	• Requires specialised equipment • Increased supervision • Reduced working time with cement stabilised layers • Accuracy of calculating quantities • Constructability	• No experience of use • Increased supervision and quality control required • Special plant required	• Increased supervision and quality control required • Difficult to achieve even distribution of stabiliser • Training required • Less flexible timing of works
Environmentally unfriendly	• Health hazard	• No additional comments	• Chemical hazards to land and workers • Pollutes rivers and air	• Handling and safety problems • Pollution problems
Other comments	• Non-availability of stabiliser	• Lack of proper specifications • Lack of expertise in chemical stabilisation	• No comments	• Construction problems • Cannot rework materials easily • Prevents establishment of vegetation

The facilitated discussion session following the presentation of the draft report highlighted the following points:

- Chemical stabilisation (mainly cement) has been used very successfully in Zambia in the past despite most of the test sections now being carbonated. This was also the experience in South Africa. However a large number of sections investigated by the CSIR as part of their project were showing signs of distress and the carbonated materials had lost strength.
- Modification of materials using 1 to 2 per cent cement has been used very successfully in Zimbabwe for many years. No ICC or equivalent test is used to determine the stabiliser requirement. Stabiliser content is determined by comparison of Texas Triaxial class for natural and modified materials.
- Carbonation is not necessarily detrimental to the performance of stabilised layers and could be material dependent. Calcretes and weathered basic igneous materials appear to give most of the problems.
- Carbonation may be a symptom or final result of other causes of failure. This could include:
  - Adoption of inappropriate test methods
  - Insufficient stabiliser added to satisfy the ICL
  - Poor workmanship
  - Inappropriate curing methods
  - Material used was unsuitable for stabilisation
- Reference should be made in the report to the durability tests developed by CSIR to identify materials likely to give a problem with carbonation.
- The ICL test is a good indicator of the amount of stabiliser to be added (ICL + 1%) and can be used for most materials. However should this indicate a stabiliser content of >5%, extreme caution should be applied as this could lead to shrinkage/block cracking. Additional durability testing will only be necessary on marginal materials where problems are suspected. All calcretes and weathered basic igneous materials should be subjected to additional testing prior to approval for use.
- The relationship between CBR and UCS needs further consideration and clarification.
- More work is needed in understanding the stabilising mechanism with calcretes.
- Construction practices such as mellowing could be detrimental.
- Should the reduced standards for natural gravels be accepted, it is likely that chemical stabilisation may not be cost-effective for low volume roads. Provision of a suitable waterproofing layer is likely to be more appropriate.

3.3 Materials inventory

Part of the research programme in Malawi and Zambia involved the establishment of an inventory of roadbuilding materials. In Zimbabwe, the information was extensive and the Materials Inventory was developed as part of the Road Data Bank which contains various information pertaining to the Zimbabwe road network.

The workshops in Zambia and Botswana were asked to highlight the uses for a materials inventory. These are summarised in Table 3-5. The workshops in Malawi and Zimbabwe were asked to highlight issues and concerns affecting the sustainability of those systems already developed. These are summarised in Table 3-6.

Table 3-5 Use of Materials Inventories

Common uses	**Country specific comments**	
	Zambia	**Botswana**
Record keeping	• Enables dissemination of information to interested partners and users	• Central record keeping • Ease of retrieval of information • Source of readily available information • Reference for future development • Ready source of information for new products
Reducing costs	• Reduced consultancy costs	• Reduced consultancy costs
Materials management	• Rapid materials location and identification	• Prospecting of materials • Easier location of materials • Input into National Geological Engineering maps
Links to other management systems	• No additional comments	• Development of pavement performance relationships for input into PMS • Support for existing Pavement Management Systems • Interface with the existing laboratory management system
Pavement management	• Input from as-built records into long term pavement performance	• Inputs into failure investigations
Specifications and Research	• Support to ongoing research • Fine-tuning local materials and design specifications • Explore benefits of existing data	• Improved inputs into design • Support to researchers • Development of local correlations
Training	• Education and training staff	• No additional comments
Revenue	• Can be used to generate revenue	• Source of new consultancy
Others	• Labour-based and regional development projects • Other disciplines	• No additional comments

Table 3-6 Sustainability of Materials Inventories

Common problems and concerns	**Country specific comments**	
	Malawi	**Zimbabwe**
Management	• Policy makers need to understand usefulness of data resource	• Must be put into current procedures
Financial support	• Donor support for system vital • Funding sources	• Poor allocation of financial resources • Requires dedicated resources to support it: Unclear how forthcoming these are • Needs constant updating with new information
End users	• Clear identification required • Poor or no access to data • User network required to collate data	• Identify users • Accessibility to users
Data application	• System needs to be used	• Encourage use and uptake • Further training on use of data • Harmonise data capture routines
Staffing and training	• High staff turnover • Staff training vital	• More trained staff at CRL
Security	• Theft	• Must establish virus checking and back ups • Secure location • Year 2000 compliance
Ownership	• Impact of reform programme	• Impact of decentralisation • Future of CRL
Marketing	• Promote system	• Needs to be marketed to stakeholders • Make available to private sector
Others	• Uncertain future of materials laboratory • Regular system maintenance, updates and upgrades • Keep abreast of IT developments	• Regular system maintenance, updates and upgrades • Must keep abreast of new IT initiatives and technology • Need to implement GPS • Need to link to GIS

The participants agreed that a materials inventory was necessary and should be linked to a larger roads database.

In Botswana, there was considerable debate about ownership and accessibility to the information. There was a strongly felt opinion that the inventory should be controlled by the Roads Department but that some of the functions in terms of updating and managing the inventory could be out-sourced. Selective information would be provided on a fee basis. This would ensure better sustainability and updating of the inventory.

In Zambia, it was felt that should an inventory be developed it should be privatised or a public/private partnership set up and controlled by the NRB. Information would also be provided on a fee basis to ensure better sustainability and updating of the inventory.

In Malawi and Zimbabwe there were genuine worries about the future of the Materials Inventories with the moves towards decentralisation and privatisation of the laboratories. The sustainability of both the Central Roads Laboratory in Zimbabwe and the Materials Branch in Malawi in a private sector environment was questioned. It was recognised that both laboratories have been under-resourced for many years and that this had had a negative impact on their ability to operate efficiently.

3.4 Environmental impact of materials extraction

There is now a greater awareness of the environmental problems associated with road provision even in developing countries and many donors are now insisting that Environmental Impact Studies must be carried out on road projects. This programme of research was aimed, mainly, at problems associated with the use of local gravels for road construction. The environmental impact of the extraction of these materials from borrow pits and the consequences arising from subsequent re-instatement practices and lack of re-instatement was investigated in the programme.

The environmental problems associated with materials extraction, identified at the workshops are summarised in Table 3-7.

The workshops also highlighted the possible benefits to the community of landscaping borrow-pits after extraction to provide a cheap water reservoir.

Table 3-7 Problems caused by materials extraction

Common problems	**Country-specific comments**			
	Zambia	**Botswana**	**Malawi**	**Zimbabwe**
Land use issues	• Loss of agricultural land • Sterilisation of land for future use • Reduction of land for agriculture and grazing	• Loss of agricultural land	• Loss of arable land • Sterilisation of land for future use • Loss of natural beauty	• Land value reduced • Agricultural land degraded
Land left in poor condition	• Permanent scar on landscape • Unnatural depressions	• Permanent scar on landscape • Aesthetic considerations	•	• Natural vegetation is not or cannot be replaced • Landscape permanently scarred
Soil erosion and drainage	• Sedimentation in water courses • Disruption of natural drainage courses	• Sedimentation in water courses • Erosion effects • Disruption of natural drainage courses	• Soil erosion intensified	• Erosion of soils • Sedimentation in water courses and dams
Safety Hazard	• Safety hazard in times of flooding	• Danger to Humans (especially children) and wildlife from drowning	• Physical danger to humans and animals • Noise and dust pollution	• Danger to Humans (especially children), livestock and wildlife from drowning • Noise, water and air pollution
Health hazard	• Stagnant water breeding mosquitoes and leading to malaria • Water pollution • Air pollution	• Stagnant water breeding mosquitoes and leading to malaria • Water pollution • Air pollution	• Stagnant water breeding mosquitoes and leading to malaria	• Stagnant water breeding mosquitoes and leading to malaria, bilharzia and other disorders
Loss of habitat for Fauna and Flora	• Deforestation • Destruction of vegetation • Disturbance of natural eco-system	• Deforestation • Destruction of vegetation • Disturbance of natural eco-system	• Deforestation • Destruction and loss of natural vegetation • Decrease in biodiversity	• Destruction of species
Contractual issues	• Lack of contract provision for reinstatement			
Other issues	• Illegal quarrying		• Impact on women	• Destruction of cultural antiquities • Impacts high in communal areas

The following additional comments were made:

- All donor-funded projects require an Environmental Impact Assessment (EIA) which is included in the contract documentation.
- Reinstatement of borrow pits is also specified but not always carried out. Botswana is now carrying out environmental audits after the contract to ensure that environmental requirements are met.
- Environmental problems associated with borrow-pit extraction are only one small part of the environmental impact of a road construction project and should not be considered in isolation.
- Environmental issues are specialised and should be dealt with by a specialist within the project team (could be a sub-consultant).
- Consideration needs to be given to opening semi-permanent borrow pits on a longer-term basis rather than continually opening and closing new pits as required.
- In Zambia, the Environmental Unit of the Roads Department will take responsibility for evaluating the borrow-pit management guidelines emanating from the project for possible inclusion into their overall environmental management documentation for roads in Zambia.
- In Botswana, Roads Department will consider the management guidelines further.
- The guidelines are with the Ministry of Environmental Affairs in Malawi, who will consider implementation pathway. NRA Operations Director to ensure relevant parts of the guidelines is included within the contact and other relevant project documentation.

3.5 Calcretes

Calcretes are important road construction materials in Botswana, western Zimbabwe, the south-west of Zambia and many other parts of southern Africa. TRL were requested to provide additional feedback on the recommended specification limits for calcretes, based on the long-term evaluation of several experimental sections in Botswana. The following comments were obtained from the workshops:

- A great deal of research has been done in Botswana over the last 20 years which needs consolidating and better dissemination leading to a review of the current design manual.
- Unless the Roads Department are prepared to include the findings in their specifications, there is very little likelihood that the consultants will put them into practice.
- Greater qualification will be required in the specifications to indicate where and when it would be appropriate to use the relaxed specifications.
- Current calcrete specifications for basecourse in Botswana require a soaked CBR of 60% for non-strategic routes. It was felt that a reduction to a soaked CBR of 30%, even for the lowest traffic category, could cause problems with materials which do not gain sufficient strength, through suction and drying-back, after compaction.
- Compaction should be at, or above, OMC to achieve the best results. Compact to refusal and derive specification limits through compaction trials.

- Mechanical stabilisation of calcretes has been used successfully in the past and should not be neglected.
- Suction, related to high Ip of the materials, was an important parameter in strength gain. Plasticity was considered to be a benefit if the pavement is kept dry.
- Despite the evidence from this and other (NPRA) trials in Botswana, some delegates felt that the risk was too high in using the proposed relaxed specifications. In particular, high Ip and high fines may cause compaction problems in the field and densities could be difficult to achieve.
- Current specification for surfacing aggregates in terms of 10% FACT (210 kN dry and 160 kN wet) were considered to be too high and the new proposed graded limits of (180kN - 130kN dry and 135kN - 100kN wet) depending on the expected traffic, were considered more realistic.

4. Outcome and Indicative Actions

4.1 Natural gravels for road construction

4.1.1 Outcomes

- The designs from the project on natural gravels were endorsed as being more appropriate than current designs for low-volume roads.
- The recommended specifications will result in more confident use of materials previously considered to be marginal, although many had already been used successfully on parts of the existing road network.
- There was general agreement that, provided water is prevented from entering the pavement, materials standards can be relaxed allowing the use of local materials with the associated cost savings.
- Sealed shoulders and a good maintenance regime will provide greater guarantees of good performance.

4.1.2 Indicative Actions

- Consideration should be given to publishing the results in an Overseas Road note to cover low volume sealed roads. In the interim, an addendum to ORN31 may be appropriate.
- There was a strong request from consultants and contractors for the designs and specifications to be written into country and regional documentation so that they could be put into practice.
- There was little information on dispersive or sodic soils and a need for research in this area was identified
- Information is needed on how to deal with expansive and collapsible soils within the context low volume roads.
- More consideration needs to given to determining realistic traffic growth rates. Unrealistically high growth rates or equivalence factors may reduce the level of risk for the engineer but results in conservative pavement designs, which can ultimately negate the feasibility of projects.

4.2 Chemically stabilised roadbase materials

4.2.1 Outcomes

- Chemical stabilisation has been used successfully throughout the region and should be retained as an option for the improvement of soils and gravels.

- While carbonation of some materials could be a problem this should not exclude the use of stabilisation. For some of these potentially problematic materials such as fine-grained calcretes and weathered basic igneous rocks, additional durability tests should be carried out to assess the likely performance of the stabilised materials in service.

- Providing the ICL of a material is satisfied and cementation takes place, there should be sufficient residual strength in the material to provide good performance even if the layer carbonates.

4.2.2 Indicative Actions

- The relationships between (DCP)CBR and UCS could provide a useful tool for assessing the residual strength of chemically stabilised pavement materials.
- Further investigative research is required with respect to the chemical stabilisation and durability of calcretes and basic igneous rocks (basalts).
- Chemical stabilisation of calcretes appears to present particular problems, which are still not fully explained. These require urgent attention in the light of currently occurring failures.
- Modification (<2%) as opposed to stabilisation (2-6%) with cement has been successfully achieved in Zimbabwe. There is need to investigate the practical benefits and cost-effectiveness of this option elsewhere.

4.3 Development of a materials inventory

4.3.1 Outcomes

- Considerable cost savings could accrue at the planning and design stage of engineering projects.
- Control and responsibility for the inventory should rest with the Government or its agent. Some of the management tasks could be contracted to the private sector and information could be provided on a fee-for-service basis.
- The materials inventory can be used as a planning tool and also as a source of information to be given to consultants and contractors. Information should be sold for cost recovery.

4.3.2 Indicative Actions

- A materials inventory should, preferably, be an integral part of a comprehensive road database.
- Hardware and software needs to be updated in Zimbabwe and Malawi.
- The materials inventory should be used in local authorities and RDC’s. This needs to be followed up.
- Materials inventories need to be continually updated, upgraded and maintained. This requires ongoing provision of adequate financial resources.
- Good laboratory management and laboratory staff training are essential to ensuring the reliability of data for a materials inventory.
- A regional strategy, perhaps co-ordinated by SATCC, could be adopted to develop centralised materials inventories for the benefit of other countries.

4.4 Environmental impact of gravel pit extraction

4.4.1 Outcomes

- The environmental, health and agricultural benefits of improved borrow pit management were agreed by the participants. The relative importances of these benefits were different in the four participating countries.
- The borrow-pit management guideline already endorsed in Malawi, was seen as a positive step forward.

4.4.2 Indicative Actions

- The relevant government departments will further evaluate its usefulness for incorporation into current documentation.
- Guidance notes on gravel pit extraction could be usefully incorporated into contract documentation
- Further developmental research work can be usefully undertaken into the use of redundant borrow areas as; waste and spoil disposal sites, small reservoirs for rural irrigation, and as bioengineering nursery areas.

Appendix A Lists of workshop participants

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