JOB CREATION, SKILLS DEVELOPMENT AND EMPOWERMENT IN ROAD CONSTRUCTION, REHABILITATION AND MAINTENANCE

A best practice manual by Gauteng Department of Public Transport, Roads and Works - Technology Development Programme

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Definition of Terms

Demographic Characteristics of Workers
The number of workers that fall within the following categories must be recorded: Youth (i.e. 18 – 35 years of age), Women, People with disabilities. The definitions contained in the Preferential Procurement Regulations of 2001 for these categories of beneficiaries will be utilised.

Elementary occupation
This relates to any occupation involving unskilled or semi-skilled work.

Job Opportunities
1 job opportunity = paid work created for an individual on an EPWP project for any period of time. In the case of social sector projects, learnerships will also constitute job opportunities. The same individual can be employed on different projects and each period of employment will be counted as a job opportunity.

Labour-intensive
Labour-intensive construction is the economically efficient employment of as great a proportion of labour as is technically feasible, throughout the construction process including the production of materials, to produce as high a standard of construction as demanded by the specification, the result being the generation of a **significant** increase in employment opportunities per unit of expenditure by comparison with conventional capital-intensive construction, without compromising cost, time ~~and~~ or quality.

Person-days of Employment Created
The number of people who worked on a project x the number of days each person worked.

Project Wage
Minimum Daily Wage Rate = daily wage (whether task-rated or time-rated) per individual project. This wage rate must be inserted in the Project tender document as per the EPWP Guidelines.

Special public works programme
A programme providing public assets through a short-term, non-permanent, labour-intensive programme initiated by government and funded from public resource.

Sustainability
In the context of this document, sustainability refers to the medium to long term creation of employment as a result of the skills development, training and experience gained during the construction of roads using labour intensive techniques.

Targeted labour
Any unemployed person who is employed on the project and classified as local labour.

Task Rate
A rate agreed, set and fixed for the project to be fair compensation for a days work.

Task
An amount of work, that can be done per day, that can be measured, has been tried, tested and agreed, for different activities and which is project specific.

Task-rated worker
Means a worker paid on the basis of the number of tasks completed.

Team balancing
The optimisation of resources applied to any operation, or set of operations comprising a project, taking cognisance of parallel and subsequent tasks and the need to keep the entire workforce optimally employed.

Glossary of Technical Terms

Aggregate (for construction)
A broad category of coarse particulate material including sand, gravel, crushed stone, slag and recycled material that forms a component of composite materials such as concrete and asphalt serving as reinforcement to add strength to the overall composite material.

Asphalt
A mixture of inert mineral matter, such as aggregate, mineral filler (if required) and bituminous binder in predetermined proportions.

Asphalt, Recycled
Asphalt which has been reclaimed from a road and with which (if required) a new binder, new aggregate and recycling additive (rejuvenator) have been mixed in predetermined proportions under hot or cold conditions depending on the type of new binder used.

Binder, Bituminous
Any bitumen based material used in road construction to bind together or to seal aggregate or soil particles.

Binder, Modified
Bitumen based material modified by the addition of compounds to enhance performance. Examples of modifiers are polymers, such as PVC, and natural or synthetic rubbers.

Bitumen
A non-crystalline solid or viscous mixture of complex hydrocarbons that possesses characteristic agglomerating properties, softens gradually when heated, is substantially soluble in trichlorethylene and is obtained from crude petroleum by refining processes.

Bitumen, Cutback
A liquid bitumen product obtained by blending penetration grade bitumen with a volatile solvent to produce rapid curing (RC) or medium curing (MC) cutbacks, depending on the volatility of the solvent used. After evaporation of the solvent, the properties of the original penetration grade bitumen become operative.

Bitumen, Penetration Grade
That fraction of the crude petroleum remaining after the refining processes which is solid or near solid at normal air temperature and which has been blended or further processed to products of varying hardness or viscosity.

Bitumen emulsion
An emulsion of bitumen and water with the addition of an emulsifier or emulsifying agent to ensure stability. Conventional bitumen emulsion most commonly used in road works has the bitumen dispersed in the water. An invert bitumen emulsion has the water dispersed in the bitumen. In the former, the bitumen is the dispersed phase and the water is the continuous phase. In the latter, the water is the dispersed phase and the bitumen is the continuous phase. The bitumen is sometimes fluxed to lower its viscosity by the addition of a suitable solvent.

Bitumen Emulsion, Anionic
An emulsion where the emulsifier is an alkaline organic salt. The bitumen globules carry a negative electrostatic charge.

Bitumen Emulsion, Cationic
An emulsion where the emulsifier is an acidic organic salt. The bitumen globules carry a positive electrostatic charge.

Bitumen Emulsion Grades
***Premix grade*:** An emulsion formulated to be more stable than spray grade emulsion and suitable for mixing with medium or coarse graded aggregate with the amount smaller than 0.075mm not exceeding 2%.
***Quick setting grade*:** An emulsion specially formulated for use with fine slurry seal type aggregates, where quick setting of the mixture is desired.
***Spray grade*:** An emulsion formulated for application by mechanical spray equipment in chip seal construction where no mixing with aggregate is required.
***Stable mix grade*:** An emulsion formulated for mixing with very fine aggregates, sand and crusher dust. Mainly used for slow-setting slurry seals and tack coats.

Bitumen Rubber
A blend of bitumen and approximately 20% by weight of crumb rubber containing, where necessary, an extender oil and/or dilutent.

Bituminous Curing Membrane
A coat of bituminous material applied to a newly constructed cemented pavement layer to promote the curing of the layer.

Bitumen Treated Base
A base layer consisting of granular material mixed together with a bituminous binder.

Cape Seal
A single application of binder and stone followed by one or two applications of slurry.

Cement (for construction)
A dry powder which on the addition of water and other additives, hardens and sets independently to bind aggregates together to produce concrete.

Cement Treated Material
A compacted layer of gravel treated with a nominal amount of cement.

Chip Seal
One or more applications of bituminous materials to a pavement surface with a cover of mineral aggregate.

Chip Seal, Single
An application of bituminous binder followed by a layer of stone or clean sand. The stone is sometimes covered with a fog spray.

Chip Seal, Double
An application of bituminous binder and stone followed by a second application of binder and stone or sand. A fog spray is sometimes applied on the second layer of aggregate.

Composite Macadam
A pavement or surfacing layer constructed where the bottom two-thirds of voids in a large single-sized stone skeleton are filled with sand and the top-third is filled with a bituminous slurry.

Concrete
A construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate such as gravel or crushed stone plus a fine aggregate such as sand), water, and chemical admixtures.

Concrete Block Paving
A course of interlocking or rectangular concrete blocks placed on a suitable base course and bedded and jointed with sand.

Crushed Stone
A form of construction aggregate, typically produced by mining a suitable rock deposit and breaking the removed rock down to the desired size using crushers.

Distributor
A vehicle comprising an insulated tank with heating and circulating facilities and a spray bar capable of applying a thin, uniform and predetermined layer of binder.

Emulsion Treated Base
Modification of sandy, granular or reclaimed pavement layers with bitumen emulsion.

Filler
Mineral matter composed of particles smaller than 0.075mm.

Foam Bitumen Treated material
A compacted layer of gravel or recycled material pretreated with foamed bitumen.

Fog Spray
A light application of diluted bitumen emulsion to the final layer of stone of a reseal or chip seal or to an existing bituminous surfacing as a maintenance treatment.

Gravel
A naturally-occurring, weathered rock within a specific particle size range. In geology, gravel is any loose rock that is larger than 2mm in its largest dimension and not more than 63 mm.

Lime Treated Material
A compacted layer of gravel treated with a nominal amount of lime.

Otta Seal
A carpet of graded aggregate spread over a freshly sprayed hot bituminous binder.

Overlay
A layer of asphalt applied to an existing surfaced road. This may be to strengthen the pavement or to improve the riding quality or skid resistance.

Polymer-Modified Bitumen
A bitumen with improved physical properties obtained by the addition of a polymer.

Prime Coat
A coat of suitable bituminous binder applied to a non-bituminous granular pavement layer as a preliminary treatment before the application of a bituminous base or surfacing. While adhesion between this layer and the bituminous base or surfacing may be promoted, the primary function of the prime coat is to assist in sealing the surface voids and bind the aggregate near the surface of the layer.

Reseal
A surface treatment applied to an existing bituminous surface.

Rejuvenator
A material (which may range from a soft bitumen to petroleum) which, when applied to reclaimed asphalt or to existing bituminous surfacing, has the ability to soften aged, hard, brittle binders.

Seal
A term frequently used instead of “reseal” or “surface treatment”. Also used in the context of “double seal” and “sand seal” where sand is used instead of stone.

Selected layers
Pavement layers of selected gravel materials used to bring the subgrade support up to the required structural standard for placing the subbase or base course

Slurry
A mix of suitably graded fine aggregate, cement or hydrated lime, bitumen emulsion and water, used for filling the voids in the final layer of stone of a new surface treatment or as a maintenance treatment (also referred to as a slurry seal).

Slurrybound Macadam
A surfacing layer constructed where the voids in single-sized stone skeleton are filled using bituminous slurry.

Surface Treatment
A general term incorporating chip seals, micro surfacing, fog sprays or tack coats.

Surfacing
The layer with which traffic makes direct contact.

Tack Coat
A coat of bituminous binder applied to a primed layer or to an existing bituminous surface as a preliminary treatment to promote adhesion between the existing surface and a subsequently applied bituminous layer.

Ultra-thin Reinforced Concrete Pavement (UTRCP)
A layer of concrete, 50 mm thick, continuously reinforced with welded wire mesh.

Wearing Course
The upper layer of a road pavement on which the traffic runs.

Waterbound Macadam
A pavement layer constructed where the voids in a large single-sized stone skeleton are filled with a fine sand.

Abbreviations

ABET:	Adult Basic Education and Training
CCC:	Contractor Contact Centres
CETA:	Construction Education and Training Authority
CIDB:	Construction Industry Development Board
COLTO:	Committee of Land Transport Officials
CSIR:	Council for Scientific and Industrial Research
DOE:	Department of Education
DOL:	Department of Labour
DPW:	Department of Public Works
ECSA:	Engineering Council of South Africa
EPWP:	Expanded Public Works Programme
ETB:	Emulsion Treated Base
FET:	Further Education and Training
FIDIC:	French acronym for the International Federation of Consulting Engineers
GDPTRW:	Gauteng Department of Public Transport, Roads and Works
GET:	General Education and Training
HET:	Higher Education and Training
ILO:	International Labour Organisation
LIC:	Labour-Intensive Construction
LICT :	Labour-Intensive Construction Techniques
MIG:	Municipal Infrastructure Grant
MISA:	Million Standard 80 kN Axles
NEC:	New Engineering Contract
NQF:	National Qualifications Framework
PIG:	Provincial Infrastructure Grant
SANS:	South African National Standard
SADC:	Southern African Development Community
SATCC:	Southern African Transport and Communications Commission
SPWP:	Special Public Works Programme
SAQA:	South African Qualifications Authority
TRH:	Technical Recommendations for Highways
TMH:	Technical Methods for Highways
UTG:	Urban Transport Guidelines
UTRCP:	Ultra-thin Reinforced Concrete Pavement

1. Introduction

1.1. Background

South Africa has historically had a high unemployment rate with Statistics South Africa reporting an unemployment rate of 25.5%[1] as of September 2006. Given that many unemployed persons are "unskilled" and that there is little demand for "unskilled" persons in the South African labour market, the challenge facing government has been to provide employment for these people. In light of this challenge, in 2003/4 government launched the Expanded Public Works Programme (EPWP) to create temporary work opportunities using public sector expenditure mainly in the infrastructure sector.

The EPWP has a target of providing employment opportunities and training for at least one million targeted unemployed people in its first five years. As a result, the infrastructure sector has had to increase the labour content on government funded projects, as part of the existing budget, through the application of appropriate labour-intensive technologies where technically and economically feasible.

The EPWP has its focus on the labour-intensive construction of low volume roads, pipelines, stormwater drains and urban sidewalks within a generally ring-fenced and isolated environment. The main reason for this is that labour-intensive construction and maintenance of roads is very often regarded as inferior due to perceived quality, costs, and productivity issues. Hence, Road Authorities generally only allocate low volume roads for labour-intensive construction and maintenance (to minimise risk of investment) at the exclusion of the larger formal construction sector.

However in the past few years, developments in appropriate labour-intensive technologies, labour optimisation and project management techniques have improved significantly to a point where it is now possible to integrate labour as a critical and measurable component for the whole of the road construction sector.

Consequently, the Gauteng Department of Public Transport, Roads and Works (GDPTRW) have developed this manual as a best-practice guideline for the formal and emerging construction sector to promote sustainable job creation and empowerment in the planning and execution of **all road construction, rehabilitation and maintenance** projects. Recommendations on the use of appropriate labour-intensive techniques are also provided to ensure that **the labour content of all projects is increased and optimised without adversely affecting the cost and quality of projects**.

It is also important to note that the construction of roads referred to in this document should not be confused with building construction referred to in CIDB documentation – there is a marked difference.

1.2. Objectives of the manual

The manual is primarily intended to provide guidance to Road Authorities and their Consultants on:

- Optimal labour components for specific design elements;
- Appropriate contract documentation, specifications and tender evaluation procedures to encourage the use of labour;
- Legal requirements related to the employment of unskilled and semi-skilled labour;
- Quality and cost of labour related to group tasks and group balancing:
- Training, mentoring and incubation programmes.

[1] **Statistics South Africa (2006) -** Using the "narrow" definition which reports on those who have been actively looking for work during the past 2 weeks. Using the "broad" definition, which includes those who have stopped looking for work, the figure rise over 40%

1.3. Benefits of the manual

The following benefits of the manual are identified:

- Optimisation of the use of labour on **all projects** (**new construction, rehabilitation and maintenance**);
- Increased sustainability of job opportunities through the optimisation of labour on all projects;
- Increased use of appropriate labour-intensive technologies;
- Increased involvement by the formal construction sector in job creation and mentoring of emerging contractors;
- Improvement in performance of the emerging sector through, training, mentoring and incubation.

1.4. Target audience

This manual is targeted primarily at pavement design engineers within Road Authorities and the consultants who are contracted to prepare pavement designs for those Authorities.

1.5. Benefits of the manual

The document is structured to provide:

- An introduction to the purpose and philosophy behind labour optimisation;
- Project selection criteria that highlight the type of construction activity and its relevance and appropriateness to labour-intensive construction;
- An indication of the typical employment potential of various road construction activities (Appendix 2 to 26). **(It should be noted that the information in these Appendices is provided for guidance and should be used with care by inexperienced practitioners. Detailed method statements for the various activities are being prepared as a supplementary document.)**
- Advice on suitable contract documentation, specification and tender evaluation procedures.(Standard forms of contract are provided in Appendix 27);
- References to available maintenance guidelines and manuals. (Details provided in Appendices 28 to 30);
- Guidelines on the legal, labour and training requirements of road construction projects including calculations of the required labour force. (Additional information and calculation examples are provided in Appendices 31 to 34).

The reference documents used in the compilation of the manual are acknowledged in the footer on the page where the reference occurs along with additional explanatory notes. Sources of additional information are given in Appendix 1.

2. The Philosophy of Labour Optimisation

Labour-intensive construction techniques in the road sector are well developed and can significantly raise the labour component of road construction projects. However, in certain instances the relationship between the labour intensity of a project and the external project constraints (i.e. time, cost and quality) are not considered simultaneously. This results in projects where either the job creation targets are not met, or where the constraints of time cost and quality are not met, or both.

Therefore, the optimum labour component for each project can and must be calculated systematically within the constraints of the project and with due consideration for what is reasonably practicable, as demonstrated in Figure 1.

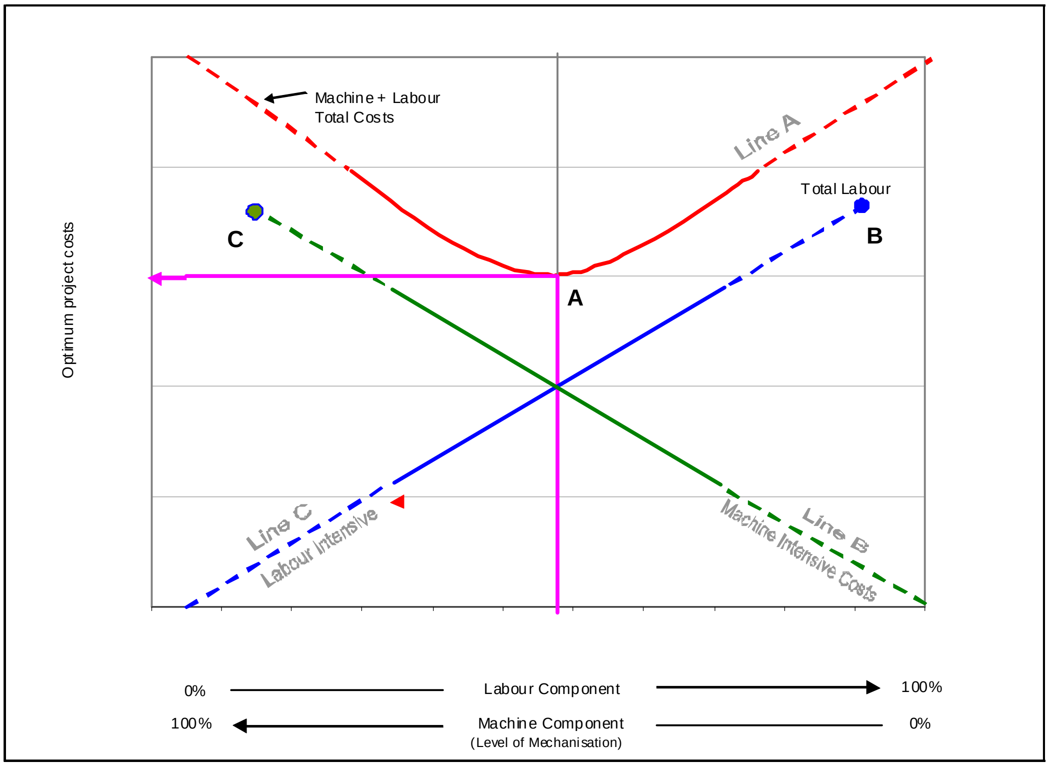

Figure 1: Principle of Labour Optimisation

The major contributors to project costs are materials, labour and plant, although the cost of materials and the labour input in their production/manufacture is not considered in the labour optimisation process.

In Figure 1, the project costs (Line A) is determined as the sum of plant costs (Line B) and labour costs (Line C). The extreme scenarios of all labour and no plant (Point B) and all plant and no labour (Point C) are plotted on a reverse scale against the project cost. The most economical project cost (Point A) is determined through an intelligent mix of labour and plant taking full cognisance of all the factors governing the project cost. Most of these factors are interdependent and as such the management thereof requires careful consideration.

The main factors influencing project cost are:

- **The Scope of Work**
  The type of project and scope thereof will significantly influence the overall labour component of the project. For example the construction of a multilane highway, will have a different labour requirement to a rural access road but could still have a significant labour component provided that the appropriate pavement design is adopted.
- **The Socio-Economic Environment**
  A profile of the potential workforce in the project area is a function of the socio-economic environment. An appreciation of this environment coupled with community inputs must be known at design stage as this will influence the design parameters and the project goals. The Scope of Work (stage and extent) in conjunction with the socio-economic environment where the project is being carried out will be the main drivers determining the labour-intensiveness of the project.
- **The Specified Quality (Design and Specification)**
  The design must specify the required quality which needs to be achieved irrespective of the level of labour intensity. Furthermore the design must encompass appropriate technologies to satisfy both the level of labour intensity and the quality required. However, it must be noted that the objective of this manual is not to relax any specifications or standards provided in COLTO (1998) but to relate the use of labour to such specifications and standards. Many clauses in the COLTO specification refer directly to the use of specific construction equipment and techniques for these uses (eg number of passes of compaction equipment). These aspects, where not appropriate to labour-intensive construction need to be identified and more appropriate statements replacing them must be added to the Special Specifications and Conditions for the specific project.
- **The Project Budget/Costs**
  The project budget must be allocated proportionally to satisfy the project goals. Tolerance towards a labour premium is advocated during the learning stage of a project. However the limits and extent thereof must be controlled.
- **The Project Construction Period (Time)**
  In many instances, employers' budgets are fixed to specific timeframes. Hence, the completion of construction within the required timeframe is of critical importance. The optimisation of labour around this constraint needs specific attention. The potential exists for the significant increase in the labour utilised on a project (coupled with supervision and management) as the projects time constrains come into play.

An understanding and acceptance of the principles of labour optimisation shown in Figure 1 will then allow for the measurable parameters to be used to determine achievable project goals (Figure 2) in terms of:

- The optimum labour component of the project (point A in figures 1 and 2) within agreed allowable tolerances as a condition of contract (shaded area in Figure 2); and
- The introduction of bonus/penalty schemes to ensure labour targets are met.

2.1. Involvement of the Wider Construction Sector

The application of the Labour Optimisation Philosophy provides a procedure that can be used to encourage the formal construction sector to create job opportunities. Reward procedures could also be developed to ensure that the conventional performance drivers of time, cost and quality are not compromised.

Appropriate labour-intensive technologies are typically those technologies with a lower mechanisation level, that are more human-friendly than conventional construction and are specifically designed and developed for construction by labour. However, certain labour-intensive technologies that are well developed with a proven service record are still used in relative isolation. Therefore, the widespread implementation of these technologies needs to be driven through facilitation by experienced personnel coupled with appropriate training.

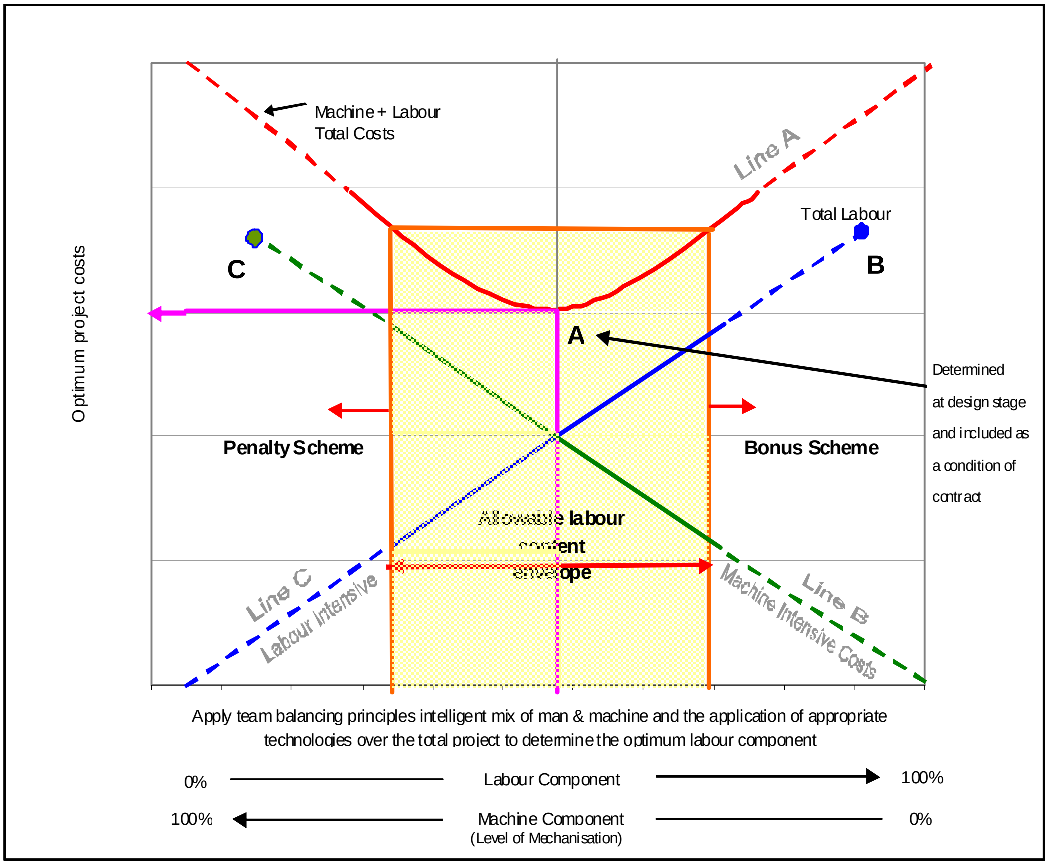

Figure 2: Determination of Achievable Project Goals through Labour Optimisation

Labour-intensive technologies also provide opportunities to the emerging construction sector due to the relatively low barriers to entry as the technologies are based on the greater use of productive labour without the high cost of purchasing machines. However, through the application of this philosophy, sustainability, growth and integration of the emerging construction industry will take place as a matter of course with the application (in conjunction with training, facilitation and mentorship) of appropriate technologies to all projects in the road construction sector.

The application of the Labour Optimisation Philosophy ensures that projects are no longer divided into "conventional" and "labour-intensive" projects, but that all projects are carried out with labour being a measurable and critical part thereof.

2.2. Sustainability of Job Creation

Experience in previous programmes, and specifically the EPWP has shown that because the jobs created were temporary in nature, skills developed during the programmes were not necessarily retained in the road construction industry. It is a specific aim of this manual to encourage the creation of sustainable (permanent) skills and jobs for the roads sector that will be achieved through:

- Increasing the total labour input on all projects;
- Increasing the skills levels of emerging contractors and labour through training, mentoring and incubation;
- Funding of labour-intensive programmes through the Departmental budget rather than through ad hoc special programmes;
- Involving the formal construction industry in labour-intensive construction, in joint venture with the emerging contractors;

- The longer term extension of job creation by ensuring that those involved in construction activities continue to be involved in maintenance activities to ensure the ongoing preservation of the road asset.

2.3. Lessons learnt[2]

Previous experience has identified factors that have lead to the successful completion, or otherwise, of projects and could provide guidelines for the future planning of long-term, large-scale programmes.

2.3.1 Success Factors

The following factors need to be considered and implemented to ensure the successful completion of a labour-intensive programme or project:

- Policy- and decision-makers at all levels must understand the concepts and principles of labour-intensive work and guidelines for large-scale programmes.
- Appropriate types of projects should be selected and planned for implementation as part of long-term programmes of construction and not undertaken as ad hoc projects. Given the nature of remuneration for engineering and project management expertise, overheads are generally extremely high on one-off projects and will inordinately distort the ratio of expenditure on engineering and managerial expertise to that of employment of skilled, semi-skilled and unskilled labour. This can only be addressed if a number of projects are designed and supervised by the same engineering/managerial component, as it takes as much high-level technical expertise for one project as it does for a number of projects in a programme. In Kenya, for example, the ratio of overheads to direct construction was 84:16 during the first three years of labour-intensive construction implementation (1974-76) but 16:84 over the period 1974-1985.[3]
- There needs to be a sound intellectual assessment of the technical feasibility and economic efficiency of labour-intensive methods taking cognisance of technological and institutional capacity. The principles of labour-intensive work should be incorporated into the daily work activities.
- Technical, institutional, organisational, managerial and socio-economic aspects should receive concentrated attention during preliminary work which should continue through pilot projects, embryonic training programmes and subsequent large-scale training and construction programmes.
  - Ø Technical matters should include design, standards of construction and maintenance, specifications, tools and equipment and methods of construction.
  - Ø Institutional matters should include the decentralisation necessary for grass roots success and the centralisation necessary to plan and co-ordinate a large programme.
  - Ø Organisational and managerial aspects should include the type of organisation required, the management structures and systems (recording, reporting, monitoring, controlling and evaluation) and training.
  - Ø Socio-economic aspects should include wage rates, conditions of employment, labour legislation, labour supply, role of women and evaluation. Prior agreement will be required between the different parties with regard to wage rates, conditions of employment and the role and responsibilities of the community.
- Strong organisations need to be established with good management systems providing a balance between decentralisation and centralisation.
- Training should be extensive and targeted specifically at the various worker categories (eg engineers, "hands-on", single- and multi-site supervisors, clerks, vehicle/tractor drivers and artisans). The expansion of the construction programme should also be integrally linked to the rate at which the training programme can realistically produce competent personnel. In effect the human resources necessary to run the programmes are generated by the programmes themselves.
- Long term financial commitment needs to be provided by Government and Donors.

[2] McCutcheon and Marshall (1998) and McCutcheon (2003: 15-56)
[3] Hagen (1985)

- There is a need for good co-ordination between government, government departments, those administering the programme, local authorities, those providing technical assistance and donors. Independent evaluation also contributed to the success, as did the continuity and commitment provided by particular individuals.

The corollary to the above is that **the programmes are not short-term relief projects**. While this anticipates a portion of the next section, it is considered of such over-riding importance that it has been highlighted again here. Experience has shown that in a relief context, it is virtually impossible to generate sustainable employment and skills; and construct sound, efficient public infrastructure. Long-term programmes and commitment are therefore essential for successful implementation.

2.3.2 Failure Factors

Analysis of projects and large-scale endeavours that were discontinued revealed the following reasons for failure:

- Very little sustainable employment was created.
- The assets constructed were not cost-effective, of doubtful value and ill-maintained with the consequence that the results have often disappeared.

The overriding failure mechanisms resulted from an array of factors, which included:

- Too many ill-defined objectives that could not be independently and verifiably measured;
- Confusion between short-term relief objectives and long-term developmental objectives;
- Inappropriate institutional structures responsible for implementation;
- "Add-on" funding as opposed to the formal procedures normally followed for the provision of public infrastructure;
- Ad hoc projects neither linked to a programme of construction nor training;
- Inappropriate definition of the scope of labour-intensity;
- Inadequate planning with, in particular, unrealistically short lead-in times between project conception and initiation of construction;
- Inadequate and inappropriate contract documentation;
- Lack of appropriate legislation (in particular employment legislation) to allow the principles of labour-intensive construction to be used;
- Little national, provincial and local institutional capacity-building along with a lack of communication between the various levels and agencies of government;
- The expenditure on development failed to reach the target group (the poor) to the extent envisaged;
- Individual skills were not improved. Training, where present, was not particularly appropriate or focused and has not shown itself to be carried through into post-project employment;
- Individual commitment to the long-term success of the project was lacking: it was seen as a short-term source of income for the community;
- Internal planning, recording, reporting, monitoring, control and evaluation were severely lacking and any independent evaluation was noticeable by its absence. Given the lack of systems for planning and monitoring, systematic evaluation (internal or independent) would have been extremely difficult anyway.

3. Project Selection

This Section deals with the overall project selection taking due consideration of the optimum balance of labour and plant as illustrated in Figures 1 and 2. The project selection process is shown in the flow chart of Figure 3.

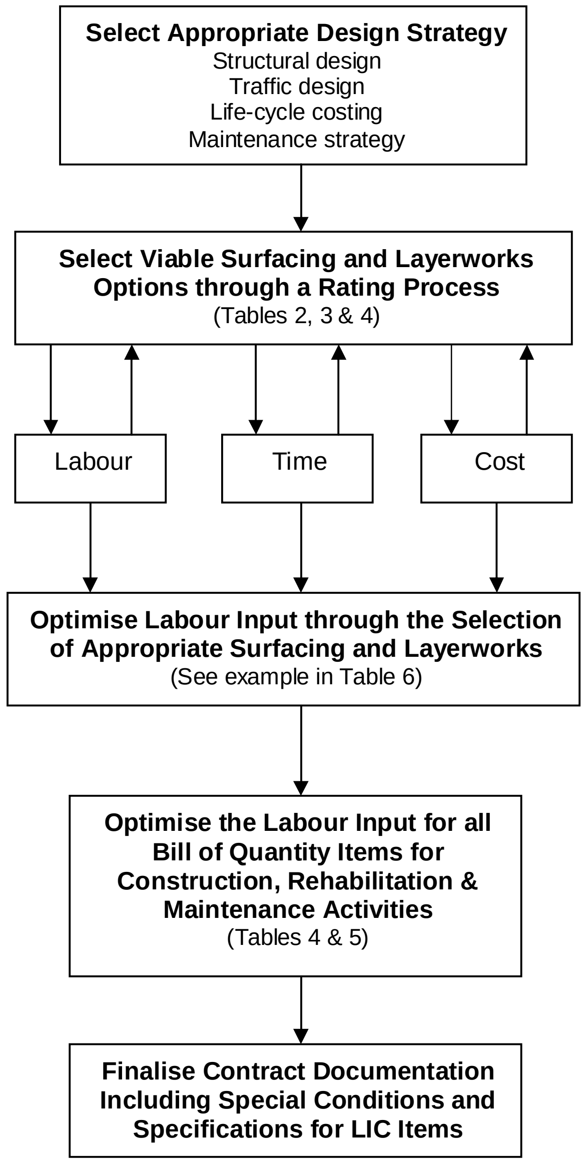

Figure 3: Project Selection Process

3.1. The Rating Process

All road infrastructure projects have the potential for labour-intensive construction and maintenance, contractor development and skills development to various degrees. It has been proven that labour-intensive construction can achieve the same level of accuracy and quality as conventional methods when designed and constructed appropriately. However, there are various stages of assessing and optimising the labour-intensity of projects, the first of which is an evaluation of the competitiveness of including appropriate labour-intensive methods compared with conventional capital-intensive construction in terms of cost, time and quality.

When analyzing the labour component of a project, a holistic approach should be followed where all parameters are rated on a scale between 1 (most favourable) and 5 (least favourable). Hence, a rating of 1 will be attractive for a particular parameter (cost, time, quality and the labour component).

When analyzing a technology or activity, the designer needs to appreciate that quality and workmanship in accordance with specifications will apply. For example, if hot mix asphalt is considered, the mechanisation level will be high. Hot mix asphalt requires a batching plant, asphalt paver and heavy rollers to construct a product in accordance with specifications. The cost parameter will therefore be rated as for the conventional and be rated as 1. Time and quality will also be as for conventional and rated 1. However, the labour component for conventional construction will be lower than 7% and therefore a rating of 5 will apply. It should also be noted that the ratings of the various parameters must be considered in isolation and not added together.

The following subjective ratings are recommended:

Cost

Equivalent to conventional methods	1
The labour alternative represents a high costs premium	3
The labour alternative represents a very high cost premium	5

Time (Production Rate)

Equivalent to conventional methods	1
The labour alternative represents a high time premium	3
The labour alternative represents a very high time premium	5

Quality (A measure of the ease at which quality similar to conventional specification can be achieved taking into account the structural integrity, functionality and riding quality)

Equivalent to conventional methods	1
The labour alternative may require moderate machine corrections	3
The labour alternative may require extensive machine corrections	5

Labour component (Calculated as a % of the unit rate)

Labour component x: ≥ 30%	1
Labour component x: ≥ 20% and < 30%	2
Labour component x: ≥ 15% and < 20%	3
Labour component x: ≥ 7% and < 15%	4
Labour component x: < 7%	5

Assuming that projects will be correctly selected in terms of labour component and that quality and cost will not be compromised; all projects and project components can be rated in terms of their suitability to increase the labour component of the project or programme.

3.2. Labour Component Targets for Project Types

Following the philosophy of labour optimisation as explained in Section 2, it is apparent that all projects must be considered as potential labour-intensive projects and that labour needs to be optimized with every project. However, it is obvious that the higher order roads will have a lower potential labour component as a lesser number of appropriate labour intensive technologies will result in compliance with the required specifications without compromising cost, time and quality. Nevertheless, the potential labour components still need to be optimized. Table 1 shows labour component targets for different project types.

Table 1: Labour Component Targets for Different Project Types

Project Type	Road category	Achievable labour component targets	Rating (labour component)
Routine Maintenance	Freeways/Highways	>30% (50%)	1
	Urban arterials	>30% (60%)	1
	Low volume, low speed roads	>30% (70%)	1
Rehabilitation	Freeways/Highways	<7%	5
	Urban arterials	7 – 15%	4
	Low volume, low speed roads	20 – 30%	2
New Construction	Freeways/Highways	<7%	5
	Urban arterials	7 – 15%	4
	Low volume, low speed roads	20 – 30%	2

3.3. Selection of Design Strategy and Optimisation

All road construction or upgrading projects are currently designed in terms of:
- Structural capacity;
- Design traffic;
- Life cycle costing;
- Maintenance strategy.

However in order to optimise the use of labour in construction, the actual design needs to take into account the labour content of the individual pavement components in terms of cost, time, quality and labour component. As a general guide, Tables 2 and 3 give an indication of the appropriateness of using labour-intensive construction for specific components of the road. (NB: Pavement Design is dealt with in more detail in Section 4):
- Table 2 provides a comparative rating of surfacings for LIC decision purposes; (further details are provided in the Appendices indicated in the table);
- Table 3 provides comparative rating of establishment, earth/layerworks and drainage for LIC decision purposes; (where available, details are provided in the Appendices indicated in the table).

It should be noted that the details provided in the relevant appendices are not intended as full method statements for the particular activities and should be used with caution. Full method statements are being developed as a supplementary document.

3.4. Illustration of Project Selection Criteria

To illustrate the proposed selection criteria, Table 4 provides an example of how **viable competing options** for construction of the basecourse for a typical road could be compared. The initial selection decision should be based on the labour component rating with the time, cost and quality ratings used to justify the final decision.

Table 2: Comparative Rating of Surfacings for LIC Decision-making Purposes

Component (COLTO spec)	Cost	Time	Quality	Labour Comp	Comments	Motivation	Appendix
Asphalt – hot (4200)	1	1	1	5	Requires batching plant + paver. Labour component optimised.	Superior strength low maintenance surface	Appendix 21
Asphalt – cold (none)	3	3	2	4	Could be laid by hand	Has shelf life and easier application	Appendix 22
Cape seal (4600)	2	1	1	3	Slurry must be squeegeed in. Bitumen emulsion should be applied through a motorised distributor or by hand sprayer	Labour friendly, forgiving construction.	Appendix 16
Concrete conventional (7100)	2	2	1	3	Could be plain or reinforced	High labour content, superior strength/life & low maintenance	Appendix 25
Ultra-thin Reinforced Concrete Pavement – UTRCP (none)	1	2	1	2	Attention need to be paid to tolerances of the supporting layer and placing the mesh in the UTRCP due to the thinness of the concrete	High labour content, superior strength/life & low maintenance	Appendix 24
Double seal (4500)	2	3	3	4	Needs accurate binder & aggregate application.	Labour-intensive aggregate application only	Appendix 17
Cold graded aggregate seal (Modified Otta) (none)	3	3	2	3	Hand sprayer can be used with emulsion	Forgiving construction & maintenance Labour-intensive aggregate application	Appendix 18
Hot graded aggregate seal (Otta) (none)	3	3	1	4	Requires spray tanker & broom back of aggregate	Forgiving construction & maintenance Labour-intensive aggregate application	Appendix 19
Sand seal (4900)	1	1	1	3	Needs attentive sand broom back & re-application	Ease of construction & maintenance	Appendix 14
Single seal (4400)	2	2	2	4	Requires accurate binder application.	Labour-intensive aggregate application only	Appendix 15
Slurry-bound Macadam	2	2	2	1	Sensitive to poor workmanship	Experienced teams can produce excellent surfacing	Appendix 23
Slurry seal (4600)	1	2	1	1	Not recommended as a first surfacing. Generally used for texture correction or overlay on an aged seal.	Labour friendly, forgiving construction.	Appendix 20
Interlocking blocks (7300)	1	1	1	4	Blocks not to be manufactured on site.	Cost of placing is small compared with cost of blocks	Appendix 26

Table 3: Comparative Rating of Establishment, Earth/Layerworks and Drainage for LIC Decision Purposes

Component (COLTO spec)	Cost	Time	Quality	Labour Comp	Comments	Motivation	Appendix
Establishment and general requirements	2	2	1	3	Relevant to all projects	Similar to conventional approaches	-
Clear & grub	5	5	1	1	Lack of progress may delay other activities	Not recommended for larger projects but could be appropriate for smaller projects	-
Drainage	3	3	1	3	Relevant to all drainage elements	Applicable on all projects	-
Bulk earthworks (3300)	5	5	5	1	Slow & demoralising work for labour	Not recommended for LIC. Labour component optimised	Appendix 2
Telford (none)	5	5	2	2	High cost and time	Not recommended	-
Cement treated gravel base & sub-base (3500)	5	5	4	1	Not for LIC - setting time restriction. HSE Restrictions	Only in emergency and on small projects for LIC	Appendix 11
Composite emulsion treated base (none)	5	5	2	1	Only top ⅓ of gravel treated	Increases strength of gravel Could be prone to excessive cracking	Appendix 6
Crushed Stone base (G1, G2) (3600)	1	1	1	5	High specification & final slush compaction with mechanical rollers Labour component optimised	Cost effective, superior base using conventional methods. Not recommended for LIC	Appendix 13
Crusher-run base & sub-base (G2/G3) (3600)	1	1	1	5	Do not relax specification & normal density requirements	Superior base if density & support is achieved Not recommended for LIC	Appendix 12
Concrete base (7100)	3	4	2	1	Base and surface layer	Slow rate of construction	Appendix 25
Rollcrete	3	4	2	3	Base and surface layer	Slow rate of construction	-
Emulsion treated base (3500)	3	3	2	2	Improves marginal materials	Good for LIC if suitable natural base material is not available. Can be trafficked prior to surfacing.	Appendix 4
Foamed bitumen treated base (none)	3	3	2	3	Static batching plant (not in-situ foaming) required for mixing and application	Superior flexible base. Can accommodate construction traffic. Mix can be stockpiled for up to 6 months	Appendix 5
Natural gravel base & sub-base (3400)	3	3	3	2	Prone to traffic damage prior to sealing	Not recommended for larger projects but is appropriate for smaller projects	Appendix 3
Macadam bases (water, slurry or bitumen bound) (none)	3	4	3	2	Costly & requires expertise. Asphalt finish for riding quality. Density not to be compromised.	Preferable for layers to be less than 8m wide	Appendix 7 Appendix 8 Appendix 9
Lime treated gravel base & sub-base (3500)	2	2	2	1	Lime treatment recommended for basic crystalline material Prone to traffic damage prior to sealing	When material improvement is required	Appendix 10
Gravel selected layers (3300)	3	3	3	2	Slow & demoralising work for labour	Not recommended for larger projects but is appropriate for smaller projects	Appendix 3

Table 4: Example of how competing options for base construction are compared

COMPONENT	LIME TREATED GRAVEL BASE PAVEMENT	CRUSHED STONE (G1) BASE PAVEMENT	EMULSION TREATED (ETB) BASE PAVEMENT
Equipment (from summaries in Appendices 10, 13 & 4)	· Wheelbarrows, shovels, rakes, measuring cans, guide & bulking rails, etc. · Transport for carting gravel · Lime storage · 150/200 concrete mixer · Suitably sized (≈ 1 ton) tandem vibratory pedestrian roller/s · Plastic cover · First aid kit and protective clothing	· Wheelbarrows, shovels, brooms manual or mechanised rotary · Transport for aggregate · Watering truck · Motor grader · Suitably sized (12-17 ton) steel drum and pneumatic roller/s · First aid kit and protective clothing	· Wheelbarrows, shovels, rakes, brooms, measuring cans, guide rails, etc. · Emulsion drums · Transport for aggregate · 150/200 concrete mixer · Suitably sized (≈ 1 ton) tandem vibratory pedestrian roller/s · First aid kit and protective clothing
Cost	**2** Equipment, lime, water, gravel. Bituminous prime required	**1** Cost optimised using conventional methods. Not recommended for LIC	**3** Equipment, emulsion, water, aggregate Saving on aggregate possible when reworking old base
Time	**2** • Fixing guide rails • Mixing in concrete mixer • Carting by wheelbarrow • Spreading/Shaping • Compaction • Taking up of guide rail • Prime -> apply surfacing	**1** Time optimised using conventional methods. Not recommended for LIC	**3** • Fixing guide rails • Mixing emulsion & aggregate • Carting in by wheelbarrow • Spreading/Shaping • Compaction • Taking up of guide rails • Apply surfacing
Quality	**2** Very little, if any, detrimental effect provided attention is given to mixing, levels and compaction – prime base as work progresses	**1** Quality optimised using conventional methods. Not recommended for LIC	**2** Eminently suited to LIC provided attention is given to mixing, levels and density. Sound gravel with 60^{+}% CBR is required No priming necessary Trafficable early
Labour Component	**1** Suitable for unskilled labour. Mixing & compaction by machine	**5** Low labour component. Requires trained labour – Shaping, compaction & slushing done by machine	**2** Suitable for unskilled labour. Mixing & compaction by machine

NB - Figures in blocks correspond to the suggested ratings given in Table 3

3.5. Road Maintenance

Although it is not the intention of the manual to address road maintenance in general some aspects related to labour-intensive applications are addressed. The importance of timely maintenance to prevent unnecessary rehabilitation and reconstruction costs with the associated reduction in road user costs is also highlighted.

Maintenance is defined as that timely corrective activity that aims to retain the functional and structural integrity of the road at its intended (design) service level and averts costly failure and repair work. It is basically a preventative activity and falls into three major categories:

- Routine maintenance
- Periodic maintenance (8 – 14 years)
- Rehabilitation

Maintenance can only effectively be achieved if undertaken on a systematic, ongoing, continuous basis as distinct from an ad hoc or crisis maintenance system that can be extremely costly.

Table 5 provides an analysis of programmable maintenance activities (daily chores) related to costs, time, quality and labour component as a guide to selecting maintenance activities with optimal labour content.

Additional information relating to the maintenance of roads and appurtenant works is provided in the references in Appendix 1 with other relevant information in the following Appendices:

- **Appendix 28** which provides some examples of community based road maintenance programmes.
- **Appendix 29** which expands on LICT 5 which is one of the sources referred to in **Appendix 1, Reference 6.**
- **Appendix 30** details a proposed method for dealing with edge break repairs which are not covered in the above.

Table 5: Analysis of programmable maintenance activities (daily chores) against costs, time, quality, suitability, labour component and application

	Costs	Time	Quality	Labour component	Application	Remarks	Motivation
Pavement maintenance							
Surfacing patching (pothole initiation) with cold mix asphalt	2	2	1	1	Surface	Recommended	Similar to conventional
Crack sealing with cold pour sealant	2	2	1	2	Surface	Recommended	Similar to conventional
Surface texturing with slurry	3	4	2	1	Surface	Recommended	Delay in traffic accommodation may favour conventional
Edge break repairs with cold mix asphalt	3	4	2	1	Surface	Recommended	Delay in traffic accommodation may favour conventional
Deep patching	4	4	3	1	Top Layers	To be avoided	Slightly different approach to the conventional
Drainage maintenance							
Subsoil drain installation	3	4	1	2	All roads	Recommended	Similar to trenching activities
Cleaning of waterway structures	2	1	1	1	All roads	Recommended	-
Cleaning of prefabricated culverts	1	1	1	1	All roads	Recommended	Similar to conventional
Hand cleaning of concrete drainage channels	1	1	1	1	All roads	Recommended	-
Hand cleaning and maintenance of existing earth channels	2	3	1	1	All roads	Recommended	-
Machine cleaning and maintenance of existing earth channels	1	1	1	4	All roads	Not recommended	Only if traffic accommodation affected
Signs & safety maintenance							
Erection of permanent road traffic signs	2	2	1	1	All roads	Recommended	Some signs may be too big to manage by hand
Sign cleaning	1	1	1	1	All roads	Recommended	-
Roadstud installation	1	1	1	2	All roads	Recommended	Coring done by machine
Guardrail erection	1	1	1	1	All roads	Recommended	Similar to conventional
Dazzle screen erection	1	1	1	1	All roads	Recommended	Similar to conventional
Marking of roadway features	2	1	1	1	All roads	Recommended	Except for centre-lines
Roadside maintenance							
Fencing	1	1	1	1	All roads	Recommended	Similar to conventional
Edge build-up (shoulders)	3	3	1	1	All roads	Recommended	Normally done by graders
Gabion protection work	1	1	1	1	All roads	Recommended	Similar to conventional
Collection and removal of debris and litter	1	1	1	1	All roads	Recommended	Similar to conventional
Maintenance of roadside stopping places	1	1	1	1	All roads	Recommended	Similar to conventional

Table 5 (continued)

	Costs	Time	Quality	Labour component	Application	Remarks	Motivation
Gravel maintenance							
Blading of gravel roads	5	5	5	1	Wearing coarse	Not recommended	Tolerances difficult to achieve, thus costly
Gravel patching	2	2	1	1	Wearing coarse	Recommended	-
Betterment of gravel roads (shaping)	5	5	5	1	Wearing coarse	Not recommended	Tolerances difficult to achieve thus costly
Regravelling of roads	5	5	5	1	Wearing coarse	Not recommended	-
Vegetation maintenance							
Controlling vegetation growth	1	1	1	1	All roads	Recommended	-
Removal of undesirable vegetation	1	1	1	1	All roads	Recommended	-
Maintenance of established plants and grassing	1	1	1	1	All roads	Recommended	-
Emergency maintenance							
Emergency repairs	2	2	1	1	All roads	Recommended	Type of repair may influence rating
Accident restoration	2	2	1	1	All roads	Recommended	Type of restoration may influence rating
Removing obstructions from the road surface	2	2	2	1		Recommended	Type of obstruction may influence rating

4. Pavement Design

The general objective of this section of the document is to identify those pavement layer alternatives that are particularly conducive to construction using labour. The aim is to assist design engineers to employ their skills, knowledge and creativity to incorporate those design components employing higher labour inputs for any specific operation into their designs.

The design components need to be related to the relevant components in the COLTO Standard Specifications for Road and Bridge Works for State Road Authorities (1998) as this will still dictate the construction standards required. The information presented here refers only to the direct labour inputs associated with a road contract and not indirect labour inputs related to the production of construction materials such as cement, concrete pipes and crushed stone which can be significant. For example, a tonne of cement has a production labour input of about 1.1 person hours and a tonne of aggregate road base an input of 0.27 person hours, whereas a 10 m section of 600 mm concrete pipe has a labour input of about 12.5 person hours.

Table 6 indicates the typical employment potential of various roadwork activities as a preliminary guide to the type of labour that could be employed (CIDB, 2002).

Table 6: Typical employment potential of various roadwork activities (CIDB, 2002)

Activity	Thickness (mm)	Person Hours to produce and construct (person h/m^2)	
		Plant-intensive	Labour-intensive
Road bed preparation (Rip and recompact)	-	0.033	0.350
Gravel wearing course (G5)	125	0.160	1.000
Base course (G4)	150	0.192	1.200
Base course (G3)	125	0.165	N/A
Subbase (G6)	150	0.192	1.200
Waterbound macadam base course	100	1.040	1.370
Slurry seal	10	0.110	2.011
Asphalt	25	0.140	1.170
Concrete blocks	60	0.930[a]	2.120[b]
a – Factory produced blocks for paving b – Based on past experience of the Cement and Concrete Institute, blocks manufactured on site using labour is **not** recommended			

It must be noted that the objective of this section is not to relax any specifications or standards provided in COLTO (1998) but to relate the use of labour to such specifications and standards. Many clauses in the COLTO specification refer directly to the use of specific construction equipment and techniques for these uses (eg number of passes of compaction equipment). These clauses, where not appropriate to labour-intensive construction, need to be identified and replaced by more appropriate statements in the Special Specifications and Conditions for the specific project.

As mentioned in Section 3.3, definitive method statements for appropriate labour-intensive activities need to be developed as a complimentary document to this manual. The information provided in the Appendices of this manual and referenced in Tables 2 and 3, is intended as preliminary guidelines to help evaluate the suitability of competing alternative activities and should be used with care by inexperienced practitioners.

4.1. Pavement design philosophy

The structural design of the pavement should follow conventional techniques, whether using national or provincial catalogue methods (eg TRH 4[4]), mechanistic empirical design techniques (Theyse, 2005[5]) or the Dynamic Cone Penetrometer (DCP) method (Kleyn 1982[6],[7]). Concrete pavement designs will usually be based on the cncPave system[8] or the low volume concrete road methods[9] while block paving would be based on UTG 2 (1987)[10] or LOCKPAVE[11]. A number of draft documents and guidelines also exist for the use of bitumen emulsions[12] and foamed bitumen[13], although foamed bitumen tends to be less labour-friendly than bitumen emulsion.

It should be noted that the design methods applied in South Africa are based on many years of experience, combined with a full scale accelerated pavement testing (APT) programme of more than 400 sections of road covering a wide variety of pavement structures, climatic and material characteristics from different regions of South Africa using Heavy Vehicle Simulators (HVS) (see Section 4.2). Although HVS testing cannot take into account the effects of time, it does simulate closely the effects of traffic over time with accelerated characteristics such as overloaded vehicles and moisture sensitivity.

An aspect that must not be underrated in the pavement design is the determination of the design traffic, bearing in mind that the design traffic is essentially a function of the heavy vehicles (in terms of E80s). There is no doubt that improvement of a road from unsealed to sealed standard attracts and generates significant heavy traffic (primarily delivery vehicles) which, *inter alia*, soon necessitates upgrading of the pavement and realignment. Hence, the underestimation of the traffic for projects of this nature should be avoided at all costs. Traffic estimation on rehabilitation projects tends to be more conventional and accurate.

The engineer must satisfy himself that the chosen design is adequate for the expected traffic and environment in the area, based on conventional design principles. The fact that some or all of the layers will be constructed using labour should have no bearing on the structural nature of the design.

The anticipated life cycle of interventions for a specific pavement have a definite bearing on the type and composition of the pavement since they will influence the constructability and the maintainability of the pavement. Thus, the road network management programme and maintenance capabilities of the client/contractor are important determining factors in the selection of pavement type. The better the construction and maintenance capabilities of the client, the less the built-in redundancy or conservatism needs to be. However, without a good maintenance capability, it may mean that optimally, the design should rather be one bearing capacity category higher to make it more maintainable. Whatever the specific situation, the construction cost must be balanced against the overall life cycle strategy cost. The decision as to whether the road will be a "run-to-death" structure or a standard well-maintained road with an extended life and with a residual value should be made early in the design process.

Alternatively, it might be more effective to plan for phased construction, starting with a light pavement (also utilising traffic compaction) and systematically increasing the bearing capacity by adding the necessary layer/s at fixed intervals or in phase with traffic growth. It should be noted that this option should only be considered when the client is fully committed to the

[4] Department of Transport. 1996. **Structural design of flexible pavements for interurban and rural roads.** Pretoria: Department of Transport. (Technical Recommendations for Highways: Draft TRH 4)
[5] Theyse,EL. 2005. Classical South African **mechanistic** empirical design method; pavement design series. Pretoria: CSIR Transportek. (TIK 7200)
[6] Kleyn EG et al. 1982. The Application of a Portable Pavement Dynamic Cone Penetrometer to Determine in situ Bearing Properties of Road Pavement Layers and Subgrades in South Africa. European Symposium on Penetration Testing, Amsterdam, Netherlands, May 1982.
[7] Kleyn, EG et al. 1987. Application of the Dynamic Cone Penetrometer (DCP) to Light Pavement Design. Department of Transport and Public Works, Gauteng.
[8] Available after registration at www.cnipave.co.za
[9] Perrie, B. 2000. Low volume concrete roads. Midrand: Cement and Concrete Institute
[10] Department of Transport. 1987. Structural design of segmental block pavements for southern Africa. Pretoria: Department of Transport (Urban Transport Guidelines: draft UTG 2)
[11] LOCKPAVE design programme – http://www.cma.org.za
[12] Sabita manual 14 (1993), GEMS – The Design and use of Granular Emulsion Mixes
[13] Asphalt Academy TG2 (2002) – Interim Technical Guideline: The Design and Use of Foam Bitumen Treated Materials

execution of the programme. In this process, areas that are weak will often show premature failure and a stronger design can be applied to these areas during the phasing programme.

The capacity and likelihood of maintaining the road properly must be an important input into the design assumptions. In a well-organised and managed road authority, maintenance operations are usually programmed to be preventative more than reactionary. In these cases, bitumen surfacings will be maintained such that, for example, regular fog sprays will be applied to keep the surfacing alive and intact (preventative and routine maintenance) and potholes are not allowed to develop as a result of poorly maintained fatigue cracking. In a poorly managed road network system, the maintenance is often restricted to patching potholes (local pavement failures) by which time the base course and even deeper layers could have become weakened through de-densification and/or water ingress. The materials selected and the pavement design needs to take aspects such as these into account.

Once viable pavement structures have been identified, and the Engineer is satisfied that the pavement will reach its design life under the design assumptions (life cycle strategy), the opportunity arises for innovation in terms of the materials and the layer types. It is at this stage that labour-intensive techniques should be considered and incorporated into the project to maximise the labour content. Materials most amenable to labour-intensive construction techniques should also be considered at this time. However, the required pavement structural properties (eg strength and stiffness) identified as part of the design process must still be achieved.

4.2. Heavy Vehicle Simulator Testing

Heavy Vehicle Simulator testing has been applied directly to a number of road sections constructed using labour-intensive methods. These include various waterbound macadam structures as well as bitumen emulsion stabilized materials tested in the Makhado (Louis Trichardt) and Cullinan areas. Labour-intensive sections of untreated ash and composite macadam were also included in these test sections. Numerous block paved road designs using labour for construction as well as concrete pavements have also been tested under the Heavy Vehicle Simulator. The results from all of these tests have been used in many of the design methods currently employed in South Africa.

The Makhado sections were constructed as part of the N1 (section 28) using a 73 mm nominal size coarse aggregate and tested using dual wheel loads. The general findings of these investigations were that the structural performance of pavements constructed using labour-intensive techniques was equivalent to those constructed conventionally. The HVS was used to apply approximately 1 million equivalent standard axles (including 100 000 repetitions under wet conditions) to the road sections. The test sections performed exceptionally well and indicated that the road had a capacity to carry about 37 million standard axles.

The road sections at Cullinan included waterbound macadam and bitumen emulsion treated materials as well as untreated ash and composite macadam sections with a conventionally constructed crushed stone control section. The HVS sections were constructed on relatively weak support structures and the sections were each subjected to up to 500 000 load repetitions. The results of testing the macadam sections indicated that the roads were easily capable of carrying more than 11 million standard axles. Generally all of the sections were capable of supporting more than 2 million standard axles. The results also indicated that an improved cost benefit ratio can be achieved if the density specifications on the waterbound macadams are not relaxed to accommodate the labour intensity.

HVS testing on labour-intensive pavement construction methods were also conducted on three concrete sections. The first series of tests took place on the N3 close to Pietermaritzburg at the Hilton off-ramp. The test sections included both dowelled and undowelled jointed sections of 150 mm thick concrete placed on a G5 supporting layer with the aim of investigating the influence of the environment and accelerated loading on joint deterioration of doweled and plain aggregate interlocking joints using quartzite and dolerite materials.

Significant outcomes from this research indicated that temperature changes have a significant effect on slab edge and corner curl. Slab curl due to differential temperatures between the top and the bottom of the slabs were as high as 0.75 mm. This effect highlighted the importance of proper concrete pavement construction techniques and proper curing methods. As expected, the doweled joints performed significantly better than the plain aggregate interlocking joints.

The second series of tests were undertaken on a 180mm Continuously Reinforced Concrete Pavement (CRCP) inlay constructed using labour intensive construction methods in the climbing lane on the N3 northbound at Town Hill. The original 180mm was placed using labour-intensive construction methods to determine the remaining life of the existing concrete in-service inlay through HVS testing. The pavement, constructed in 1998, had carried approximately 6.5 million standard axle loads at the time of testing and, due to the presence of a significant cracking of the pavement, it became important to determine how long the structure would last before major rehabilitation would be required. The section was subjected to 340 000 repetitions using a 60 kN load followed by 223 000 repetitions using a 80 kN load. Due to the slow rate of deterioration, water was introduced to all cracks from 130 000 repetitions onwards. Even with the aggressive loading and the introduction of water very little additional damage was detected and by using a damage factor of 4.2, the pavement was subjected to 5.9 million E80s in addition to the 6.5 million prior to the start of HVS testing. After the completion of the test, the pavement was still not considered to have failed.

The benefits of HVS testing are clearly illustrated by this study. Due to the presence of a significant cracking pattern it was thought that the pavement had reached the end of its structural life. Through HVS testing it was discovered that the pavement has not yet failed and that a significant amount of traffic could still be carried before any major rehabilitation would be required.

The third series of concrete-related tests to evaluate the success of labour-intensive pavement construction methods is the HVS evaluation of ultra thin (up to 50mm thick) continuously reinforced concrete to be used as an overlay for the rehabilitation of moderate to high traffic roads. The HVS was used to test the structural strength of a customised concrete mix with substantial steel reinforcement. The whole construction process is done by labour except for the mixing of the concrete and the tests were carried out on the N3 Southbound at the Traffic Control Centre near Heidelberg. The tests have shown that with proper construction methods and good quality control this type of overlay will be suited to a traffic demand of over 30million equivalent standard axles with little preparation required to the existing pavement. The results from the testing have encouraged SANRAL to include this type of rehabilitation strategy in some of their rehabilitation tenders in Gauteng in 2008.

Block paved road designs were tested in the late 1970s and early 1980s[14] culminating in the publication of UTG 2. Similarly, concrete roads using various thicknesses, as well as various configurations of steel reinforcement and dowels have been tested using the HVS more recently with the findings being incorporated in the cncPave design method.

There is no doubt that the use of the HVS to assess pavements such as these allows significantly more confidence in the development of details for documents such as this one. Unfortunately, only a limited number of labour-intensive roads have so far been tested with the HVS. However, most of the basic pavement structures in use today have been assessed and fine-tuned with the HVS over the years. Thus, there should be no doubt that they are sound and should perform well, provided construction quality standards are upheld.

[14] Shackel B. 1980. The evaluation and design of interlocking concrete block pavements subjected to road traffic. Pretoria: CSIR NITRR (Technical Report RP/9/80)

4.3. Guide to material selection

There is a large range of possible material types for any specific layer in sealed roads. The variety typically increases for layers as they approach the surface of the road, with low cost natural materials typically being used in the lower layers (fill and selected), more costly treated materials for the subbase and/or base and a wide range of higher cost surfacing options for the wearing course that actually interacts with the vehicle tyres.

The structural design of the pavement (Section 4.1) will dictate the number of pavement layers and the thicknesses and strengths of each individual layer. The quality of the *in situ* material will dictate which and how many of the layers will have to be imported but irrespective of this, the controlled pavement depth should not be less than 600 mm for flexible pavements, although this depth may be reduced in some circumstances for rigid pavements.

Typical pavement designs will be similar to those provided in the catalogue of designs in TRH 4, UTG 2, cncPave or the design manual of the Gauteng Department of Public Transport, Roads and Works. Other pavement designs based on less widely used design methods (see Section 4.1) can also be used providing they carry the approval of the Client. The different materials for the various layers are summarised in Table 7.

Table 7: Different materials for pavement layers

Layer	Typical materials proposed
Surfacing	Surface treatment (seals) Asphalt Slurry-bound Macadam Surfacing Concrete Block paving
Base	Natural gravel Mechanically stabilized natural gravel Crushed stone Crusher run Chemically stabilized gravel (lime or cement) Bitumen emulsion treated gravel/aggregate Foam bitumen treated gravel/aggregate Waterbound macadam Slurry-bound Macadam Hot-mix asphalt Composite Macadam Concrete Rollcrete
Subbase	Natural gravel Chemically stabilized gravel (lime or cement)
Selected layers	Natural gravel Chemically stabilized gravel (lime or cement)

Table 8 summarises a range of labour-intensive alternatives for the conventional materials shown in Table 7. It should also be noted that in many cases, a layer of one material of a specified design thickness can be replaced directly by a different material of the same thickness. It is equally important to recognise that a thick layer or two layers of different material can be replaced by a thinner layer of a stronger material, within the constraints of maintaining an acceptable pavement strength-balance. However, when the replacement of one material with another is considered to optimise the labour component, the influence on the life cycle maintenance strategy/cost and possibly the service life of the pavement could change significantly and needs to be taken into consideration.

The importance of the maintenance capacity of the road authority in the area for which the road is planned is critical to the choice of surfacing and cannot be over emphasised. Experience has shown[15] that if maintenance is likely to be infrequent and of low quality, it is far more effective to provide a thicker, more durable seal (eg asphalt or Cape seal) during construction than to accept the likely failure of thinner seals, with relatively lower construction costs (eg sand and single seals), as a result of poor maintenance practice.

In order to optimise the use of labour-intensive techniques, the engineer needs to consider the final structural design in the light of whether the individual layers selected are the most effective in creating employment (see Tables 2 and 3). Each layer needs to be assessed in terms of whether there are more labour friendly alternatives (see example in Table 4), without detrimentally affecting the costs, the construction time (the use of more labour on site shortens the time component) or the quality of the finished product.

In this context, every project could have a number of design alternatives and those that increase the labour component without sacrificing the design objective and life cycle cost, should be proposed to the client for consideration.

Typical examples of alternative pavement designs for two traffic categories (0.03-0.1 MISA and 1-3 MISA) are shown in Table 9. For each alternative design, an assessment of the optimum labour components for each layer should be undertaken using Tables 2 and 3.

Despite the guidance given in this, and any other design documents, the final design requires the Engineer to use the knowledge and judgment gained through experience to ensure that the final structure is the best/optimised engineering solution, within the constraints of the project requirements. In other words, one does not now design "low cost" as this is a misnomer that implies that the design engineer is normally not optimising all aspects in his design. However, there are areas where the in-situ/local materials are of such quality/availability that road building in that specific location may cost less than in other areas. The designer should be mindful of this and utilise it to his advantage when it occurs.

[15] Sabita Manual 10:- Appropriate Standards for Bituminous Surfacings

Table 8: Alternative technologies particularly amenable to labour-intensive construction

Layer	Conventional Option		Labour-intensive alternative	Comments
Surfacing	Surface treatment	Sand Seal	No alternatives but activities can be optimised	Potential to increase labour activities by spreading sand by hand or using manually operated chip spreader and hand spraying with emulsion
		Slurry Seals	No alternatives but activities can be optimised	Not recommended as a first seal. Potential to increase labour activities by mixing and laying by hand
		Stone Seals	No alternatives but activities can be optimised	Potential to increase labour activities by spreading aggregate by hand or using a manually operated chip spreader and hand spraying with emulsion
		Cape Seal	Slurry-bound Macadam (SBM)	Tack spray can be applied by hand if using emulsion. Aggregate can be applied using a manually operated chip spreader and the slurry can be mixed and spread by hand. Minimum thickness 15 mm for SBM
	Asphalt		Slurry-bound Macadam	SBM less flexible than asphalt Alternative for high traffic volumes at low speeds on rigid pavements (research ongoing)
			Cape Seal	Alternative for high traffic volumes at all speeds. See comments under Cape Seals above.
			Block paving	Total pavement design and associated costs need to be considered
			Concrete	Consider total pavement design and associated costs. Combined base and surfacing.
	Concrete		Slurry-bound Macadam	See comments for SBM above. Minimum thickness of 15mm applies
			Block paving	
	Block paving		Slurry-bound Macadam	See comments for SBM above. Minimum thickness of 15mm applies
			Concrete	Higher labour component with long maintenance-free life cycle. Higher cost.
Base	Crushed stone		Dry/Water-bound Macadam	Heavy rollers required to achieve density specifications. No relaxation of density specifications
			Composite Macadams	Heavy rollers required to achieve density specifications.
			Slurry-bound Macadam	Costly if thicker than 50mm
			Emulsion Treated Base	Labour intensity is equivalent to crusher-run except for lower volume roads where labour component can be increased.
			Concrete	High labour component. Combined base and wearing course
	Cemented Gravel		Dry/Water-bound Macadam	See comment above
			Composite Macadams	Combined base and wearing course Heavy rollers required to achieve density specifications. No relaxation of density specifications
			Emulsion Treated Base	Similar labour intensity except for low volume roads where labour component can be increased
			Foam Treated Base	Requires specialised mixing equipment
			Concrete	High labour component. Combined base and wearing course.

Table 9: Examples of Alternative Designs

Traffic Category	Layer	Conventional Design	Labour-intensive Designs	
			Alternative 1	Alternative 2
0.1 – 0.3 MISA	Surfacing	13.2/6.7 Double Seal	13.2 mm Cape Seal	50 mm UTRCP
	Base	125 mm C4	100 mm Waterbound Macadam	50 mm ETB
	Subbase	125 mm G6	150 mm G5	100 mm G6
1.0 - 3.0 MISA	Surfacing	30 mm Asphalt	30 mm Slurrybound Macadam	80 mm Concrete Blocks
	Base	!50 mm G1	150 mm ETB	100 mm C4
	Subbase	200 mm C4	200 mm C4	100 mm C4

4.4. General

It should be noted that a number of the options provided in this document are not included in the current COLTO Standard Specifications for Road and Bridge Works for State Road Authorities[16] and should be provided for in the special requirements of the project specifications. It is essential that the Engineer takes note of this and ensures that the project documentation is compatible with the Standard Conditions of Contract and Specifications.

In line with accepted practice for all civil engineering projects, a labour optimized project must be completed in accordance with the specifications irrespective of the labour intensity of the construction methodology or technologies used. In addition, the project team (contractor and consultant) must comply with, and achieve, the requirements set in terms of costs, quality, and time. The importance of producing the required quality as specified in the standard specifications cannot be overemphasised. In fact in some cases, it may be necessary to include additional quality requirements and checks in the project specification to ensure that the quality is maintained in all steps of the construction process. Job lots, defined by a days work or task, will often be smaller than those using conventional plant-based construction. This, in itself, will ensure that a relatively higher intensity of quality control is applied to the labour-intensive component of the project.

On any project the specifications form an integral part of the overall project design. As such the design of the works needs to be undertaken as part of a well defined and holistic process. The workforce must be dealt with as a design parameter in terms of size, training and sustainable opportunities. A balanced consideration of this and all the other design parameters must be carried out to ensure that the project and labour utilization specifications are realistic and achievable. Over-emphasis on one parameter may sacrifice another; for example, over emphasis on job creation may sacrifice quality and vice versa. Over emphasis on quality may sacrifice costs resulting in too conservative designs. Research, development and innovation must be encouraged within this balanced approach.

The application of the technologies discussed in this document must be applied in practice in accordance with the norms and specifications applied in the industry. Limitations inherent to labour-intensive techniques may be easily overcome by specially designed equipment (eg the introduction of a spinning straight edge beam on guide rails to eliminate the irregularities associated with narrow plate vibrators on any bituminous slurry road surfaces). Further consideration should be given to:

- Verifying the level of expertise available for the project;
- Developing definitive method statements for all appropriate labour-intensive activities;
- Instituting the necessary training to achieve the level of expertise required;
- Prompt observation and correction of sub-standard work while the extent is still relatively small;

[16] COLTO. 1998. **Standard Specifications for Road and Bridge Works for State Road Authorities.** Midrand: SAICE

- Ensuring specifications are suitable and are strictly applied;
- Defining milestones with written approvals by site supervision;
- Tolerance towards machine corrections to labour-intensive tasks.

Summaries of each of the possible design alternatives for the various layers and the advantages/disadvantages of each are provided in Appendices 2 – 26. **However, as mentioned earlier, these Appendices are included for guidance in the absence of definitive method statements for the various activities and should be used with care.**

5 Contract documentation, specification and tender evaluation

As stated previously, one of the major objectives of government is to reduce unemployment and create job opportunities. As such, the construction industry, of which the road construction sector is a significant part, has been identified as a major contributor to achieving this objective. Hence, the sector will need to review its current implementation models and develop more innovative designs for future construction, rehabilitation, maintenance and upgrading of the road network. However, as with all major changes with philosophy and approaches, in order to manage change effectively, outputs must be measurable.

The various implementation models that need to be considered will dictate that different types of contract documentation, specifications and tender evaluation procedures will be required. Typical examples of different implementation models are the:

- Design-and-construct (turnkey) implementation model;
- Construction management model.

The unique features of any of these implementation models will dictate different documentation suites with different measurable milestones. Typically, the optimum labour content can be disclosed as a design condition/specification offered by the tenderers on a score-sheet to be weighted during tender evaluation. The labour component proposed by the successful tenderer must become a condition of contract and must be measured during the execution of the work. Bonus incentives or penalties can be introduced for compliance or non-compliance.

The introduction of the Expanded Public Works Programme (EPWP) is a government initiative to create temporary work opportunities using public sector expenditure and has its own preferred contract documentation and specifications supported through legislation to protect the principles of job-creation. However, this manual goes beyond the aim of the EPWP in that all road construction projects, irrespective of size, will be sensitised towards job-creation. The experience gained as part of the development of the EPWP in order to break out of the previous ring-fenced labour-intensive programmes will provide valuable inputs for this manual.

Currently, all public sector bodies involved in the provision of infrastructure are expected to contribute to the EPWP that was formally launched by the State President in January 2004. This introductory section outlines the policy framework within which the EPWP contracts of the Gauteng Department of Public Transport, Roads and Works should be formulated to conform to government objectives.

The EPWP is one of governments short to medium-term programmes aimed at alleviating and reducing unemployment through the provision of work opportunities coupled with appropriate training. It is a national programme covering all spheres of government and state owned enterprises.

The programme involves re-orientating line function budgets so that government expenditure results in more work opportunities, particularly for unskilled labour. EPWP projects will therefore be funded through the normal budgetary process of line-function departments, provinces and municipalities and opportunities for implementing the EPWP have been identified in the infrastructure, environmental, social and economic sectors. In the infrastructure sector the emphasis is on creating additional work opportunities through the introduction of labour-intensive construction methods.

Labour-intensive construction methods involve the use of an appropriate mix of labour and machines, with a preference for labour where technically and economically feasible, without compromising the quality of the product. International and local experience has shown that, with well-trained supervisory staff and an appropriate employment framework, labour-intensive methods can be used successfully for infrastructure projects.

To further encourage the use of labour-intensive methods, national government, through the 2004 Division of Revenue Act, has placed some additional conditionalities on provinces and municipalities through the Provincial Infrastructure Grant (PIG) and the Municipal Infrastructure Grant (MIG). The conditionalities require provinces and municipalities to use the “Guidelines for the implementation of labour-intensive infrastructure projects under the EPWP” agreed upon between SALGA, national treasury and the Department of Public Works for identification, design and construction of projects financed through the MIG or PIG. The guidelines aim to provide provinces and municipalities with the necessary tools to successfully tender for these projects as labour-intensive projects and provide the basis for the contractual documentation that Gauteng Department of Public Transport, Roads and Works needs to include in its own EPWP documentation.

Details of the EPWP requirements are provided in Appendix 31. Sections in this Appendix outline the legislation which has enabled the EPWP to be initiated and summarise the main aspects of the EPWP as they relate to the activities of Gauteng Department of Public Transport, Roads and Works.

5.1 Contract documentation

Road authorities may still apply the standard contract documents, conditions and specifications they are familiar with. However, depending on the type of management model, specific conditions must be drafted to protect the defined labour-component of the project. The principle that “*to measure outputs is essential to efficiently manage*” must be applied in drafting contract conditions and specifications. In addition it must be easy and simple to measure the required outcomes, and the required labour component should be indicated in the relevant specifications and bill of quantities against the specific item or activity.

5.1.1 Contract conditions and specifications

To increase the labour-component on a project does not imply that the standard conditions and specifications can no longer be used. It only implies that the labour-intensity of a project is better designed, specified and measured. This will result in certain special conditions and the use of appropriate technologies without sacrificing any of the other project goals in terms of quality, delivery time and costs.

In the early 1990s, the responsibility to increase job creation was taken by a few labour-intensive practitioners who researched the subject to such an extent that several new technologies have been developed and applied on special projects. The labour component of some existing technologies was increased and the technical performance of some of the technologies constructed using a higher labour component were thoroughly tested using the Gauteng Heavy Vehicle Simulator (HVS). The status of specifications for these technologies is in various degrees of completeness, but most can be found in the CIDB – Best Practice guides.

Research and development of these technologies is still ongoing and the authorities need to identify those specialists for consultation and use as mentors when labour-intensive technologies are specified.

In terms of the COLTO Standard Specification associated with conventional technologies, these may still be used provided that the targeted labour-components are clearly defined and protected as conditions of contract with suitable measurement and reporting systems.

6 Labour Requirements and Organisation of Construction and Maintenance Projects

The importance of correctly estimating the amount of labour for specific projects cannot be over-emphasised and this aspect will be covered in detail in section 6.5 under group tasks and balancing. Other items covered in this chapter include:

- Legislation related to the productive implementation of labour-intensive methods of construction (including mandatory training requirements);
- Community involvement;
- Rates of pay;
- Site control including the use of trained NQF4 Construction Processes Site Supervisors.

6.1 Legislation

In 2002, the fundamental basis for the productive implementation of labour-intensive methods of construction was laid down by government when it amended the 1997 Basic Conditions of Employment Act. On 25 January 2002 the Government Gazette (No. 23045) of South Africa published the following:

- No R63 Basic Conditions of Employment Act, 1997
  - Ministerial Determination: Special Public Works Programmes

and

- No R64 Basic Conditions of Employment Act, 1997
  - Code of Good Practice for Employment and Conditions of Work for Special Public Works Programmes.

Details of the relevant labour laws are provided in Appendix 32 and cover the standard terms and conditions for workers employed in elementary occupations on a Special Public Works Programme (SPWP). Some of the main features are:

- In the Ministerial Determination (R63), *inter alia*, the following is stated:
  - "Special public works programme" means a programme to provide public assets through a short-term, non-permanent, labour-intensive programme initiated by government and funded from public resources;
  - "task" means a fixed quantity of work;
  - "task-based work" means work in which a worker is paid a fixed rate for performing a task;
  - Workers on a SPWP are employed on temporary basis.
  - A worker may NOT be employed for longer than 24 months in any five-year cycle on a SPWP.
  - Employment on a SPWP does not qualify as employment as a contributor for the purposes of the Unemployment Insurance Act 30 of 1966.
- The Schedule "Code of Good Practice" (R64) included, *inter alia*:
  - A SPWP is a short-term, non-permanent; labour-intensive programme initiated by government and funded either fully or partially[17], from public resources to create a public asset.
  - On the task-based system, a worker is only paid for each task completed.
  - A "no work – no pay" rule must apply except in the following circumstances:
    - Injury and illness
  - Training is regarded as a critical component of SPWP. Every SPWP must have a clear training programme that strives to ensure a minimum of 2 days training for every 22 days worked.

6.1.1 Employment of Unskilled and Semi-skilled Workers in Labour-Intensive Works

The following requirements are identified for the sourcing and engagement of labour:

[17] Emphasis added

- Unskilled and semi-skilled labour required for the execution of all labour-intensive works shall be engaged strictly in accordance with prevailing legislation and SANS 1914-5, Participation of Targeted Labour.
- The rate of pay set for the SPWP will be determined by the public body in terms of clause 2.2 of the SANS Guidelines.
- Tasks established by the contractor must be such that:
  - the average worker completes 5 tasks per week in 40 hours or less; and
  - the weakest worker completes 5 tasks per week in 55 hours or less.
- The contractor must revise the time taken to complete a task whenever it is established that the time taken to complete a weekly task is not within the requirements of the above.
- The Contractor shall, through all available community structures, inform the local community of the labour-intensive works and the employment opportunities presented thereby. Preference must be given to people with previous practical experience in construction and/or who come from households:
  - where the head of the household has less than a primary school education;
  - that have less than one full time person earning an income;
  - where subsistence agriculture is the source of income.
  - who are not in receipt of any social security pension income.
- The Contractor shall endeavour to ensure that the expenditure on the employment of temporary workers is in the following proportions:
  - 60 % women;
  - 20% youth who are between the ages of 18 and 25; and
  - 2% on persons with disabilities.

Specific provisions pertaining to SANS 1914-5 include:

- Definition of targeted labour:
  - Unemployed persons who are employed as local labour on the project.
- Contract participation goals:
  - There is no specified contract participation goal for the contract. The contract participation goal shall be measured in the performance of the contract to enable the employment provided to targeted labour to be quantified.
  - The wages and allowances used to calculate the contract participation goal shall, with respect to both time-rated and task-rated workers, comprise all wages paid and any training allowance paid in respect of agreed training programmes.
- Terms and conditions for the engagement of targeted labour.
  - Further to the provisions of clause 3.3.2 of SANS 1914-5, written contracts shall be entered into with targeted labour.
- Variations to SANS 1914-5:
  - The definition for net amount shall be amended as follows: Financial value of the contract upon completion, exclusive of any value added tax or sales tax which the law requires the employer to pay the contractor.
  - The schedule referred to in 5.2 shall in addition reflect the status of targeted labour as women, youth and persons with disabilities and the number of days of formal training provided to targeted labour.

In terms of training of targeted labour, the following provisions are made:

- The contractor shall provide all the necessary on-the-job training to targeted labour to enable such labour to master the basic work techniques required to undertake the work in accordance with the requirements of the contract in a manner that does not compromise worker health and safety.
- The cost of the formal training of targeted labour will be funded by the local office of the Department of Labour. This training will take place as close to the project site as practically possible. The contractor must access this training by informing the relevant regional office of the Department of Labour in writing, within 14 days of being awarded the contract, of the likely number of persons that will undergo training and when such

training is required. The Employer and the Department of Public Works must be furnished with a copy of this request.
- The contractor shall do nothing to dissuade targeted labour from participating in training programmes and shall take all reasonable steps to ensure that each beneficiary is provided with two days of formal training for every 22 days worked.
- An allowance equal to 100% of the task rate or daily rate shall be paid by the contractor to workers who attend formal training, in terms of the above.
- Proof of compliance with the requirements of the above must be provided by the Contractor to the Employer prior to submission of the final payment certificate.

6.2 Community involvement

The community should be fully involved and agreement must be reached on the following:
- nature of project;
- level of service;
- method of construction;
- availability of labour;
- selection of trainees and workers;
- wage rates; and
- conditions of employment.

In addition, community agreement will be required on issues such as their willingness to accept instructions from a trained, “hands-on” site manager (the NQF4 Construction Processes Site Supervisor).

At the Pre-feasibility Report Stage the responsibility lies with the consultant to demonstrate that the proposed project has a chance of success with particular reference to the following aspects of community participation:
- Acceptance by the community of:
  - type and quality of product (the level of service);
  - cost implications;
  - method of construction;
  - remuneration;
  - conditions of employment;
  - targeting for recruitment;
  - training;
  - taking instructions from trained “hands-on” site supervisors.
- Availability of skills required for the project within the community;
- Suitability of the proposed project to be constructed.

6.3 Rates of Pay

In accordance with the Code of Good Practice for Employment and Conditions of Work for Special Public Works Programmes (clause 10.4), the public body must set a rate of pay (task-rate) for workers to be employed on the labour-intensive projects.

Clause 10.4 requires that the following should be considered when setting rates of pay for workers:
- The rate set should take into account wages paid for comparable unskilled work in the local area per sector, if necessary.
- The rate should be an appropriate wage to offer an incentive for work to reward effort provided and to ensure a reasonable quality of work. It should not be more than the average local rate to ensure people are not recruited away from other employment and jobs with longer-term prospects.
- Men, women, disabled persons and the aged must receive the same pay for work of equal value.

Experience since the publication of the Guidelines has revealed that setting the wage rate below the construction minimum, although agreed with the community prior to the start of work, has led to problems during project implementation. Thus, despite the latitude allowed by the Guidelines as regards the setting of the wage rate, it is strongly recommended that the wage rate should be set at the standard construction minimum as specified for the particular area in which the project is being constructed.

6.4 NQF4 Construction Processes: Site Supervisor

One of the principles of labour-intensive construction is that the labourer must accept the instructions of a trained "hands on" supervisor. In South Africa this is a person who has a formal NQF4 qualification as a Construction Processes Site Supervisor.

The selection and training process of the "hands on" site supervisor requires particular and detailed attention. The minimum educational level for consideration is Grade 12 with at least Grade 10 Mathematics and Science. Following an orientation period of at least one month, prospective trainees are carefully selected. Those selected must, in public, formally commit to participation in the forthcoming training programme. Thereafter, for at least one year, classroom and site training alternates on a daily or weekly basis. At the same time as the technical training related to road construction, receive additional training related to numeracy, literacy and life skills. The year of concentrated training is followed by 6 months to a year[18] of probation with an established contractor. Upon fulfilment of the requirements the person obtains the NQF4: Construction Processes Site Supervisor qualification. This qualification is recognized industry wide.[19]

The above process must be followed for full competence to be acquired. Some authorities have found that it is possible to attain limited specific capabilities in a shorter period of time. However, this training would not lead to the full NQF4 qualification.

6.5 Group Tasks and Balancing

The productivity of individual pieces of equipment and the balancing of different pieces of equipment in order that the equipment does not sit idle forms a standard part of the planning for conventional machine-based civil construction. Every hour that a piece of equipment is idle incurs a cost to the contractor. Thus, considerable attention should be paid to both the productivity of individual pieces of equipment and the balancing of the different pieces of equipment used in an operation in order to achieve a uniform output without hiatus (discontinuities; queues; idle machinery). For example, in a cut and fill operation, the number of dozers must be balanced with the appropriate number of loaders, trucks, graders, bowsers and rollers.

The same attention should be paid to the use of labour, especially in relation to technically simple, low-volume rural road construction where the concepts of individual tasks, and balancing the number of people engaged upon easily measurable activities, has been a cornerstone of good practice. However, as the required standard of road construction increases, it becomes more difficult, not only to set individual tasks for different activities but also to monitor outputs and productivity. Therefore, it becomes increasingly more important to set and monitor group tasks as opposed to individual tasks.

This section will first discuss individual tasks and elementary balancing of activities within an operation followed by a description and discussion of how to set group tasks where it is necessary to consider the balancing of the team required to construct a whole project. A team balancing exercise leads not only to the delineation of what will be done, when and by how many workers, but also to an estimate of the actual cost of labour. The final example in this section will indicate how the size of team will vary depending upon the time scale of the

[18] The length of time varies depending upon the speed with which the probationer is capable of attaining the level of responsibility and competence necessary to fulfil the requirements of the full NQF 4 qualification for a Construction Processes Site Supervisor.

[19] By taking further electives, such as concrete or water, the person becomes even more able to access employment opportunities in the construction industry

project (or vice-versa, if the number of available workers is limited and one needs to estimate the length of the construction period) and how its members should be distributed among the different operations.

6.5.1 Individual Tasks

One of the major problems for the organisation and management of labour-intensive construction has been the delineation of a group task for a complex operation.

For clearly definable activities it has been possible to set individual tasks required to be completed in a working day. The output required for individual tasks has been determined using the procedures set out in the International Labour Organisation (ILO) manual on Work Studies (1981). Extensive large-scale, long-term experience has shown that workers who have been informed that they may leave the site upon completion of an individual task generally complete a planned eight hour task in about six hours.

Individual piece rates have been defined in two ways:
- multiples of individual daily tasks; or
- multiples of fractions of individual daily tasks (mini-daily tasks).

Using individual piece rates, higher productivities have been achieved compared with those obtained through setting individual task rates.

In operations comprising clearly definable and measurable individual activities, it has been relatively easy to balance the numbers of people who should be engaged on the different activities. For example, balancing parts of a simple earthworks operation such as the cut and fill of clearly definable (and measurable) geometric shapes as shown in Table 9.

Table 10: Balancing earth works operation

Activity	Unit	Task	Workers	Balanced Output
Excavation	m^3	3	4	12
Load	m^3	6	2	12
Spread	m^3	12	1	12
			7	

A team of seven balanced between the different activities would produce a steady output of $12m^3$ of material spread in one day. The length of spread material required per day would be clearly definable and measurable. For example, assuming a carriageway width of six metres and a surfacing thickness of 100 mm, the length to be spread each day (the individual task for spreading) would be as follows:

$$\text{Length} = \frac{12{,}00}{6{,}00 \times 0{,}10} = 20\,metres$$

This type of balancing has been accepted practice for parts of relatively simple work such as the construction of low-cost, low-volume rural roads in rolling terrain and it is possible for the road-builder/”hands-on” site supervisor, to organise such portions of the work around geometrical shapes which were clearly definable and measurable usually by length alone.

However, even for this relatively low level of sophistication, it is only practical to set specific individual tasks for about 60% of the work force. Nonetheless, the rate of work of those on individual tasks means that workers engaged on other activities, such as carrying water and setting out, have to keep pace with the individual task workers.

The need for linking payment to production via the settling of individual tasks is better known now than it used to be. However, the corollary that this can only apply to about 60% of the work force is not as widely appreciated and there have been many examples of unsuccessful attempts to set individual tasks for all activities and operations. Similarly, this lack of appreciation has extended to group tasks.

6.5.2 Group Tasks

The more sophisticated the activities and operations that are required to produce a final product, the more difficult it is to:

- set individual tasks; and
- check whether these tasks have been completed correctly.

Therefore, as the sophistication of activities and operations increases, it becomes necessary to set group tasks. This requires attention to at least three components:

- a delineation of the activities which comprise an operation;
- knowledge of the output which may reasonably be expected for each activity;
- a balance between the workers engaged on the different activities which comprise an operation.

When setting a group task in a new community, it is important that the project management is sufficiently experienced to know what should be achievable by a balanced group. Inexperience at this time could lead to too high or too low tasks being set. The setting of too high tasks could lead to unfair exploitation and demoralisation of the work force while too low a task could result in poor productivity by the work force and conflict with management. In addition, experience has shown that when too low a task is set it is more difficult to get that team to accept higher group tasks at a later date.

Thus, it is important right from the start to at least be able to set tasks that are achievable based on the experience of the available work force. With an inexperienced work force from a new community, it is unlikely that the group will achieve its full capabilities until it has gained some experience.

With regard to more complex work, this can only be achieved through prior, iterative, work and method studies, to ascertain the appropriate balance and a resultant achievable group task. It will probably be possible to delineate a core balance for some significant activities. However, it is also likely that a proportion of the work force will have to carry out several different types of activity during the working day in order to keep the production process moving forward smoothly. Generally, it is unlikely that a work force will independently be able to allocate its resources and therefore, analysis and organisation will be required by management to achieve an optimal balance to achieve the required group output.

6.5.3 Group Task Balancing

A methodology was developed by Little (1993) to enable management to set appropriate group tasks for a set of different activities which together comprise a complex construction operation. This methodology has been modified as shown in Appendix 33.

In section 6.5.1, a simple example is provided for the balancing and team size required for only the excavation, load and spread components of a full gravelling operation. For each of these activities, it is possible to clearly define an individual task and check that it has been adequately completed.

The methodology described in Appendix 33 allows for the calculation of a reasonable task for a group busy with a set of linked activities (as part of a construction operation) that may not be as clearly defined or controlled on an individual basis. The methodology, together with appropriate work and method studies, enables the engineer to obtain an estimate of what a well organised group could achieve in carrying out the nine activities that comprise the transverse cut and fill component operation required to construct the formation of an engineered earth road.

Using the methodology in the appendix, it would also be possible to calculate the length of time required by a certain size of team to construct this component for a particular length of road. For example, it has been shown that one labourer would be able to construct 2.61 linear metres of 12.3 metre wide water-based macadam in one day. Thus, a team of 20 workers would take:

$$\frac{1000}{2,61} \text{x} \frac{1}{20} = 19,16$$

days to construct one kilometre.

6.5.4 *Quantity and Cost of Labour for a Project*

Croswell and McCutcheon (2003) defined team balancing as:

"*The optimisation of resources applied to any operation, or set of operations comprising a project, taking cognisance of parallel and subsequent tasks and the need to keep the entire workforce optimally employed*".

In order to manage labour-intensive work, the calculation of the group task for an operation comprising individual or several linked activities must be carried out for each item in the Bill of Quantities. In many cases, it will be found that the number of activities required for an operation is greater than those described in the Bill of Quantities. The calculation of group tasks for all the different operations provides the basis for daily site management. Without individual or group tasks being clearly set by management, it is not possible to have a well run site with cost-effective operations.

The calculation of individual or group tasks for each item in the Bill also provides the basis upon which the designer and the Contractor can estimate the total amount of labour required for the whole project and the cost of that labour.

In order to be able to estimate labour requirements and labour costs, both the designer and the contractor need to be able to estimate the total number of people who will be engaged in the implementation of the project. This exercise would be similar to the estimations carried out using conventional capital intensive methods for design and tendering purposes. However, in the case of projects using labour-intensive methods, several problems have been encountered with the calculation of estimates submitted by the consultants and the contractors. The following problems were identified:

- Estimators had little or no prior experience of labour-intensive construction and were ignorant, or unsure of how to implement such methods effectively.
- Estimates were based on negative perceptions of what could reasonably be achieved, with estimates of individual productivities often being far lower than those at the lower end of accepted productivity rates.
- Individual tasks were set where group tasks would have been more appropriate indicating that the concept of a group task is not fully appreciated to optimally balance the workers between the different linked activities of an operation.
- A balance was not achieved between the sizes of the different groups of workers required for the different operations which made up a project.

It should also be noted that where inaccurate estimates of resource requirements are made, either at the design or tendering stage, or both, this could have serious consequences for the project. Where the resource estimation is too low, this will result in an underestimation of the productivities to be achieved on site and, consequently, uncompetitive cost estimates for the project. This, in turn, will lead to inappropriate decisions being made regarding the suitability of a labour-intensive approach for certain contracts. Equally, where the number of workers employed is too high this could lead to sub-optimal productivity and standing time.

Experience has therefore indicated that successful design, tender, planning and implementation, require an accurate assessments of:

- The total number of individual tasks that have to be performed in order to complete a project.
- The total labour costs required to complete a project obtained by multiplying the total number of tasks by the daily wage.
- The optimum number of labourers required to perform the works included in a particular contract.

In order to obtain the above, it is necessary to examine the operations within a project and assess the number of labourers required for the different operations as follows:

- Obtain a balance between the different numbers of workers engaged upon linked activities within an operation.
- Obtain an understanding of the variation in the total number of workers from the different groups of workers engaged on different operations, throughout the timeframe of the contract, and smooth the totals as far as is practicable.
- Adjust the number of workers required to complete the works depending on the time frame of the contract.

The importance of the above for good planning and implementation, demands the use of a formalised and reproducible method to establish the above parameters. A methodology to perform the estimation and monitoring function, has been developed by Croswell and McCutcheon (Appendix 34) that clearly indicates the thought processes required in order to obtain an understanding of what is required where, along with the resultant resource implications. Miyanadeniya has developed a methodology which concentrates upon obtaining a balance between the different operations for various sizes of team; this also enables estimates of the way the time for completion varies with size of team.

Team balancing as indicated in Appendix 34 was developed to:

- Aid the thinking through of the construction process in relation to the Bill of Quantities, thereby assessing and balancing the workers within and between operations.
- Obtain an estimate of the total number of tasks required to complete a project. This leads directly to estimate of total labour cost.
- Aid monitoring and control of labour during the project by both the contractor and the consultant.

6.5.5 Project Size of Team and Team Balancing

Miyanadeniya has developed a methodology for obtaining a balance between operations that is essentially an extension of the Little method and based on the use of a spreadsheet to estimate the effect of different sizes of team on the length of time required for the contract. The process is as follows:

- Calculate the amount of labour required for each operation to be completed in one day. This could be per kilometre or per total length of road to be constructed and Miyanadeniya chose the total length of road.
- Calculate of the total number of workers required to complete the work in one day along with the proportion of labourers required for each operation.
- Set a total team size.
- Calculate the number of workers who should be engaged on each separate operation to achieve a balanced production.
- Calculate the time required by a size of team to complete the work required by dividing the total number required to do the work in one day by the chosen team size.

It should be noted that the number of labourers obtained from the above analysis for each work operation should be rounded off to the nearest or best possible whole number. The above system provides a guide to the estimated optimal numbers of labourers who should be allocated to each operation, assuming the activities within each operation are balanced.

The example in Appendix 35 demonstrates the results of Miyanadeniya's research on the construction of the 13 kilometres of waterbound macadam basecourse for sections of the N1 between Matoks and Louis Trichardt. The productivities used resulted from research involving detailed iterative work and method studies.

6.5.6 Summary

One of the greatest impediments to the acceptance of labour-intensive contracting is the perception that it is impossible to estimate the cost of the works accurately. Attempts at providing budgets have often been no better than guesses with very little reproducible engineering calculation being done. The reasons for this are numerous, of which several have already been mentioned and include a general lack of understanding of how much work can be done using labour-intensive techniques. In addition, the requirement that labour-intensive techniques should be used, has, in the absence of competence and a pre-feasibility analysis, led to the application of operations for which they are not suited. However, the main reason for poor estimates is that there is insufficient and inappropriate analysis of the work make-up of particular operations at the time of the preliminary design and estimation combined with a lack of consideration of the way that different operations may be most efficiently combined to complete the project.

The involvement of an experienced practitioner in the decision on the works that could be undertaken using labour-intensive construction will ensure that projects are constructed in the most economical way possible.

In the section on individual tasks it was shown that a balance could be achieved between the numbers of people required to excavate, load and spread. It was also shown that this concept could be extended to obtain group tasks for a set of linked activities which comprise an operation. This concept is then extended to apply to all operations that comprise the Work Breakdown Structure for the whole project. This simple tool optimises the size of the team and therefore the cost of labour.

Practitioners tasked with creating a budget using this analysis should be able to create a realistic budget. An added advantage is that it generates a reproducible trail relating to the make-up of the budget and can be examined critically at a later stage, either for comparisons or to provide input for future contract budgeting. It must be stressed that at the design stage estimating can only be undertaken by people experienced in both the ability of workers to perform particular tasks and the capacity of the equipment which will be required. An example is the general lack of understanding as to the capacity of a normal wheelbarrow and the capacity of an individual to move such a wheelbarrow when it is full of earth. Unrealistic expectations of productivity may well give a false sense of a lower budget; however such mistakes must invariably lead to the increasing costs and/or delay in completion of the project.

From a tenderers point of view the advantages are similar. If a rigorous analysis is carried out of the input required and the labour component which should optimise the operation, the tenderer will not only understand the quantum of the contract, but is more likely to accurately price the tender. It has been found that, after an initial period of careful education and mentoring, the discipline enforced by completing team balancing schedules, provides a far greater understanding of what contracting is all about and becomes an invaluable tool for tenderers. It is possible for contractors to return to team balancing schedules once a contract is under way to verify their initial assumptions or to make adjustments necessitated by actual experience. Furthermore, if adequate requirements regarding the provision of reporting data are included in the contract, then the information used by a tenderer to win a contract, or used by a contractor to analyse ongoing performance, can provide a useful database for other similar projects in a particular area.

Certain programmes which seek to provide training for small contractors and employment generation, such as the Social Fund for Development in Egypt, provide an opportunity for a particular contractor to refer back to earlier assumptions and analysis of contract. Having reference to team balancing schedules, the contractor is empowered to provide improved performance, both practically and financially, during the cycle of training.

As indicated previously, it is important that the "hands-on" site supervisor is able to set reasonable and achievable tasks. Provided that workers accept that tasks are reasonable, they are generally prepared to accept that actual site conditions might sometimes be more demanding, as long as the opposite is applied in easier conditions. A range of tasks for many basic construction activities is shown in Chapter 3.

Finally, in relation to the setting of tasks Croswell and McCutcheon found that the question of hardness or difficulty to excavate is always raised by the engineers. They have found that an alternative interpretation of the results from the Dynamic Cone Penetrometer test can be used as a simple tool to provide an on-site assessment of material hardness.

7 Training, Mentoring and Incubation

The Division of Revenue Act of 2004 made it mandatory to construct certain categories of publicly funded infrastructure such as low-cost, low-volume rural and urban roads, pedestrian and cycle paths, stormwater drainage and trenches using labour-intensive methods. This forms a key component of South Africa's Expanded Public Works Programme.

In sub-Saharan Africa large-scale, long-term programmes of labour-intensive road construction and maintenance have been implemented in several countries including Kenya, Botswana, Lesotho, Zambia and Malawi. In all of these programmes, the introduction of labour-intensive construction, and later maintenance**,** methods **was integrally linked to a formal training programme**.

The training programmes produced the human resources required to plan, organise and implement the work. Through this formal linking of construction, maintenance and training programmes, institutional capacity has been established in parallel with the human resources required to implement the work from site level through to large-scale planning and coordination. The institution has grown its own organisational capacities to deliver its objectives.

In these examples, particular attention was paid to the depth and extent of training of the "hands-on" site supervisor whose duty it was to be on site to organise the work of the labourers on a day-to-day basis. In order to achieve the specified standards of construction, efficiently and cost effectively, the site supervisor has to be on site all day, every day.

In South Africa, the need for training at all levels has been recognised in the formulation of the EPWP. The "Conditionalities" in the Division of Revenue Act specified that the consultant and contractor must have passed accredited NQF 5 or 7 Skills Programmes. The senior technical and managerial personnel are being equipped to plan and manage labour-intensive programmes and projects. Equally, contractors must employ supervisors who have obtained the NQF4 Construction Processes Site Supervisor qualification. But there is a huge difference in the time and effort required to fulfil the requirements for an NQF 5 or 7 Skills Programme (70/170 hours) compared to those required for the NQF4 supervisor qualification (12 to 18 months depending upon the training methodology adopted).

In this manual the following is emphasised:

- Labour-intensive construction is a sophisticated method of providing infrastructure;
- The need for quality training at all levels, but especially that of the hands-on site supervisor is essential;
- A fully trained, hands-on site supervisor is critical to the efficient and cost effective delivery through labour-intensive methods;
- A long-term programme approach is required that integrates construction and training.

The 'critical importance' of the above issues is directly related to the negative perceptions commonly levelled at labour-intensive construction, namely that it 'takes too long, costs too much, is of inferior quality, and that it is a management nightmare'. If the upper levels of technical and managerial inputs are satisfactory (ie proper engineering and effective management) then the only question of choice between machine or labour orientated delivery lies in the implementation at site level. The proper selection and training of the 'hands-on' site supervisor ensures that where appropriate, the work will be carried out at least as well by human power as by machines.

The South African Qualifications Authority (SAQA) and the Department of Public Works (DPW) have identified the need for training in labour-intensive construction at all National Qualifications Framework (NQF) levels and have therefore developed accredited training at levels 2, 4, 5 and 7.

The Construction Education and Training Authority (CETA) learnerships for labour-intensive contractors (CCO2 qualification) will also contribute significantly to building capacity for the execution of these types of work and learnerships in the Infrastructure fields have been made available through CETA and DPW.

The NQF is summarised in Table 10.

Table 11: National Qualifications Framework (NQF)

<table>
<tr><th>NQF Band</th><th>NQF level</th><th>Position</th><th>Education and Training Institutions</th><th>Qualification</th></tr>
<tr><td rowspan="4">Higher Education & Training</td><td>8</td><td rowspan="2">To Promote</td><td rowspan="4">Tertiary Institutions
Research Organisations</td><td rowspan="4">Doctorates
Masters Degrees
Degrees
Diplomas</td></tr>
<tr><td>7</td></tr>
<tr><td>6</td><td rowspan="2">To Manage</td></tr>
<tr><td>5</td></tr>
<tr><td rowspan="3">Further Education & Training</td><td>4</td><td>To Supervise</td><td rowspan="3">FET colleges
Secondary schools
Industry training providers
NGOs</td><td rowspan="3">Grade 10 -12
Standard 8 – 10
Short courses
College certificates
Workplace certificates</td></tr>
<tr><td>3</td><td>To Construct/Build (artisans)</td></tr>
<tr><td>2</td><td>To Execute (workers)
Advanced plant operations</td></tr>
<tr><td>General Education & Training</td><td>1</td><td>To Execute (workers)
Small plant operations</td><td>Compulsory schooling
Adult Basic Education & Training (ABET)</td><td>Grade 0 – 9
Standard 1 - 7
ABET 1 - 4</td></tr>
</table>

7.1 Recommended skills programmes

7.1.1 Public sector client bodies

It is recommended that personnel within public sector bodies complete skills programmes for NQF registered unit standards, as set out in Table 11.

Table 12: Skills programme for public sector client bodies

Personnel	NQF	Unit Standard Title	Skills Programme Description
Senior management and professionals	7	Develop and Promote Labour-Intensive Construction Strategies	Skills Programme against this single unit standard
Middle management (technical)	5	Manage Labour-Intensive Construction Projects	Skills Programme against this single unit standard
Middle management (admin)	5	Manage Labour-Intensive Construction Projects	Skills Programme against this single unit standard

7.1.2 Consultants

The person responsible for the design and documentation of labour-intensive works must have completed or be registered on a skills programme for the NQF level 7 unit standard "Develop and Promote Labour-Intensive Construction Strategies" (Table 12).

The individual responsible to the employer for the administration of the contract must have completed, or be registered on, a skills programme for the NQF level 5 unit standard "Manage Labour-Intensive Construction Projects" (Table 12)

Table 13: Skills programme for consultants

Personnel	NQF	Unit standard Title	Skills Programme Description
Designer	7	Develop and Promote Labour-Intensive Construction Strategies	Skills Programme against this single unit standard
Administrator Site Supervisor	5	Manage Labour-Intensive Construction Projects	Skills Programme against this single unit standard

7.1.3 Contractors

The unit standards for contractors are outlined in Table 13.

For established contractors, the site agent/manager (i.e. the contractors' most senior representative that is resident on the site) must have completed, or be registered on a skills programme for the NQF level 5 unit standard "Manage Labour-Intensive Construction Projects". For emerging contractors, the emerging contractor himself or herself must have completed, or be registered on a learnership for the NQF level 2 qualification.

For both established and emerging contractors, all other site supervisory staff (i.e. team leaders or foremen) must have completed, or be registered on a learnership for the NQF level 4 qualification.

Table 14: Unit standards for contractors

Personnel	NQF	Unit standard Titles	Skills Programme Description
Team Leader / Supervisor	2	Apply Labour-Intensive Construction Systems and Techniques to Work Activities	This unit standard must be completed
		Use Labour-Intensive Construction Methods to Construct and Maintain Roads and Stormwater Drainage	**Plus** any one of these 3 listed unit standards must be completed
		Use Labour-Intensive Construction Methods to Construct and Maintain Water and Sanitation Services	
		Use Labour-Intensive Construction Methods to Construct, Repair and Maintain Structures	
Foreman / Supervisor	4	Implement Labour-Intensive Construction Systems and Techniques	This unit standard must be completed
		Use Labour-Intensive Construction Methods to Construct and Maintain Roads and Stormwater Drainage	**Plus** any one of these 3 listed unit standards must be completed
		Use Labour-Intensive Construction Methods to Construct and Maintain Water and Sanitation Services	
		Use Labour-Intensive Construction Methods to Construct, Repair and Maintain Structures	
Site Agent/ Manager	5	Manage Labour-Intensive Construction Processes	Skills Programme against this single unit standard

7.2 Recommended Learnerships

The following learnerships/qualifications are recommended at the various NQF levels:

- NQF 2: National Certificate In Construction Contracting - (NQF No. 20813) Total Credits: 179
- NQF 4: National Certificate in Supervision of Civil Engineering Construction Processes: Roadworks - (NQF No. 23674) Total Credits: 352
- NQF 5: National Diploma in Management of Civil Engineering Construction Processes - (NQF No. 23683) Total Credits: 298
- NQF 7: Develop and promote labour-intensive construction strategies.

Details related to the learnerships can be obtained on the CETA website www.ceta.org.za under Qualifications & Unit Standards.

7.3 Training of Workers and Exit Strategies

The nature of the labour-intensive construction industry is such that projects, and therefore employment opportunities for labourers typically only last 4 to 6 months.

Based on the Code of Good practice for Special Works Programmes, this entitles labourers to only 8 to 12 days of paid training. This is insufficient to train unskilled labourers to become artisans. It has therefore been agreed with the Department of Labour to create a generic 10 to 14 day training course that will consist of accredited unit standards on:

- General Life skills,
- Awareness of HIV and AIDS
- Labour markets and the world of work.

During the course workers will also be provided with information about opportunities in learnerships and internships that are offered through various SETA's and the private sector. In addition information about further education and training opportunities, especially for youth will be coordinated together with the Department of Education. The Umsobumvu Youth Fund will also assist with the identification and creation of exit strategies for youth.

Approved training providers can be obtained from www.ceta.org.za (quality assurance - NQF/EPWP Providers)

7.4 ABET Training

ABET training (levels 1-4) in communications and mathematics is available to assist individuals that do not have the literacy and numeracy skills to participate in technical training.

7.5 Mentoring

DPW and CETA have compiled a roster of approved mentors. Mentors are required to demonstrate that they have the necessary construction and business administrative knowledge, experience and are conversant with labour-intensive construction methods. The success of the learnership depends on the implementation of related knowledge in the workplace. The mentor plays a vital role in this regard. Support to the learners should reduce over time as the learner gets more experience. Training providers and mentors will be required to provide full reporting on support, mentorship provided and progress made by learners.

DPW will appoint a mentor at the start of each contractor learnership from the approved roster compiled by DPW and the CETA. The mentor will be appointed for the entire learnership period, so that the learner contractor can receive advice in managing and running the business even if no contracts are being executed. If the learner is not happy with the appointed mentor, an application to change mentors can be made. This application will be assessed by DPW and CETA and if it is concluded that there are legitimate reasons for switching mentors, a different mentor will be appointed.

The main role of the mentor is to support the learner contractor and to impart knowledge that will enable the contractor to compete independently as soon as possible. The mentor will have to provide a wide range of support and advice functions including but not limited to:

- Advising, coaching, counselling, guiding, teaching, instructing and tutoring a Leaner Contracting Company in the execution of duties associated with a project, with particular reference to the three absolutes of project management; namely cost, time and quality related to the following:
  - financial and contractual matters;
  - the management and the development of a business;
  - the procurement of materials and services;
  - tendering for Projects;
  - concluding a contract with the Public Body;
  - construction planning and management;
  - materials management and control;
  - cash flow management;
  - the relationship between tender prices, productivity and profit;
  - the fulfilling of statutory and tax obligations with particular reference to labour and health and safety obligations; and
  - wages and salaries.
- Advising a Learner Contracting Company on the nature of the works and the contents of the procurement documents for a project, along with advice and assistance in methods of costing and tendering;
- Visiting the site at appropriate intervals during the various stages of construction in order to confirm that the Learner Contractor Company makes satisfactory progress, shows technical competence in the execution of all aspects of the works and fulfils all contractual obligations;
- Facilitating the establishment and implementation of a systematic quality assurance programme by a Learner Contracting Company on all Projects;
- Assisting the Learner Contracting Company with queries related to the interpretation of drawings, specifications and contractual matters pertaining to a project.
- Co-signing of all cheques made out by the Learner Contracting Company.
- Monitoring remedial work undertaken by the Learner Contracting Company during the defects liability period and providing any advice that is necessary.

Appendix 1: SOURCES OF ADDITIONAL INFORMATION

The following sources provide comprehensive information in respect of the following topics:

Best practice guide			
Manual/Guideline	**Aim**	**Availability**	**Ref.**
Low-volume Sealed Roads (July 2003) (SATCC)	The SATCC has published these guidelines to promote a more holistic approach to the provision of low volume sealed roads and the use of innovative best practice from the region which will lead to the more efficient use of available road funding. The aim of the guidelines is to provide appropriate specifications and technical information to enable clients and practitioners to make confidant and informed choices in project design and implementation.	The publishers of this document are: Southern African Development Community (SADC) SADC House Private Bag 0095 Gaberone BOTSWANA Tel: 09267 3951 863 Fax: 09267 3972 848 E-mail: registry@sadc.int It is the intention for the document to be available on the SATCC website www.sadc.int	
Labour-based methods and technologies for employment intensive construction work – a CIDB guide to best practice	The CIDB has published these guidelines in fulfilment of its mandate to "establish and promote best practice and the improved performance of participants in the construction delivery process". The guidelines present current state-of-the-art practices in a wide range of labour based construction methods, manufacturing methods and technologies which have been utilised in South Africa in recent years. The aim of the guidelines is to provide appropriate specifications and technical information to enable clients and practitioners to make confidant and informed choices in project design and implementation.	The best practice guide is available on the CIDB website www.cidb.org.za and can also be obtained in hard-copy from the CIDB or the South African Institution of Civil Engineers (SAICE) (www.civils.org.za)	
Implementing employment intensive road works – a CIDB practice guideline	These manuals were compiled by the CSIR in collaboration with and funding from the ILO and CIDB to promote the implementation of employment intensive road works. The primary aim of the manuals is to provide contractors involved in the construction of roads using labour and light plant with a "how to" guide to enable them to successfully construct these roads. The aim of this series of manuals is twofold, namely to provide a: • Contractors construction guide, and a • Designers and supervisors guide for contractors, designers and supervisors involved in the construction and upgrading of roads using labour and light plant.	The CIDB is in the process of finalising the publication of the manuals. The set of manuals making up the practice guide is currently available in draft form on the cidb website www.cidb.org.za. Under Job Creation - Labour based construction and upgrading of low volume rural roads.	

Manual/Guideline	Aim	Availability	Ref.
Labour-Intensive Construction Techniques: LICT 7: Upgrading Techniques for Low Volume Roads/Streets	This document is the 7th in an 8 part manual on maintaining and upgrading streets using labour-intensive methods. The processes and methods described in this volume are intended for use on streets where typical traffic volumes are below 500 vehicles per day, with less than 10% of these being heavy trucks.	LICT 7 is available from the South African National Roads Agency Ltd (SANRAL) – Ditsela Place, 1204 Park Street, Corner Park and Duncan Streets, Hatfield, Pretoria	
Routine maintenance guidance manual (June 2000)(SANRAL)	The intention of this manual is not to provide a set of specifications but to provide guidelines for the route manager to assist him in being able to identify problems and thereafter make logical decisions in selecting appropriate actions/repair methods to carry out routine maintenance Some practical repair manuals and extracts are included in the documents as appendices.	The Routine maintenance guidance manual is available from the South African National Roads Agency Ltd (SANRAL) – Ditsela Place, 1204 Park Street, Corner Park and Duncan Streets, Hatfield, Pretoria	
Labour-Intensive Construction Techniques (LICT 5): Maintenance of surfaced roads/streets	These manuals form part of an 8 part series designed to address the art of maintaining and upgrading roads/streets using labour-intensive methodS	LICT 3, 5 and 6 are available from the South African National Roads Agency Ltd (SANRAL) – Ditsela Place, 1204 Park Street, Corner Park and Duncan Streets, Hatfield, Pretoria	
Labour-Intensive Construction Techniques (LICT 6): Maintenance of concrete pavements			
Labour-Intensive Construction Techniques (LICT 3): Principles and techniques for drainage			
Code of Code of Good Practice for Employment and Conditions of Work for Special Public Works Programmes Ministerial Determination: Special Public Works Programmes	Conditions of Employment	EPWP Unit of the Department of Public Works	21
McCutcheon, RT (ed) (1993). Interim Guidelines for employment-intensive construction projects. Construction and Development Series Number 2, Midrand: Development Bank of Southern Africa, February 1993	Labour-intensive projects and programmes	Development Bank of Southern Africa	
McCutcheon, RT and Marshall J (1996). Labour-intensive Construction and Maintenance of Rural Roads : Guidelines for the Training of Road Builders, Construction and Development Series, Number 14 Development Bank of Southern Africa	Labour-intensive projects and programmes	Development Bank of Southern Africa	
McCutcheon, RT and Marshall J (1998). Institution, organisation and management for large-scale, employment-intensive road construction and maintenance programmes. Construction and Development Series Number 15. Midrand: Development Bank of Southern Africa	Labour-intensive projects and programmes	School of Civil Engineering, University of the Witwatersrand	3, 5

Manual/Guideline	Aim	Availability	Ref.
McCutcheon, RT and Taylor Parkins FLM (ed). Employment and high – standard infrastructure. Work Research Centre for Employment Creation in Construction (2003)		WORK Research Centre School of Civil and Environmental Engineering, University of the Witwatersrand	
Wage determination for the Civil Engineering Sector	Minimum wages	www.safcec.org.za under the section "human resources"	
SANS 10396, Implementing Preferential Procurement Policies Using Targeted Procurement Procedures § Annex G: Implementing employment intensive infrastructure projects which target the increase of employment opportunities generated per unit of expenditure § Annex J: Third party management support	Monitoring the employment of workers / compliance with the provisions of SANS 1914-5	Standards South Africa (division of the South African Bureau of Standards)	
Macleod, Concrete Block Paved Roads: The Development Potential .Construction and Development .Series, Number 8. Development Bank .of Southern. Africa. September, 1993	Concrete Block Paved Roads	Development Bank of Southern Africa.	18
Methods and Procedures Labour Enhanced. Construction for Bituminous surfacings Manual 12, March 1993. SABITA.	Bituminous Surfacings	Southern African Bitumen Association.	
Methods and Procedures Labour Enhanced. Construction for Bituminous surfacings Manual 11`, March 1993. SABITA.	Bituminous Surfacings	Southern African Bitumen Association.	
CIDB Best Practice Guidelines for Procurement C1: Preparing Procurement Documents SANS 10403, Formatting and Compilation of Construction Procurement Documents	Preparing procurement documents	Construction Industry Development Board www.cidb.org.za under the section "job creation"	
All relevant South African National Standards	Standards and specifications	Standards South Africa (division of the South African Bureau of Standards)	
Bituminous Pavement Repairs TRIP May 1997	Training manual for conducting labour-intensive repairs of bituminous roads	Southern Africa Bitumen Association	

Appendix 2: EARTHWORKS/FILLS

1. Definition

- Fills of imported material required to correct poor geometry or raise level of pavement.

2. Application

- Support layers for all categories of roads.

3. Advantages / Disadvantages

- (A) : Can employ large numbers of unskilled labourers
- (D) : Can involve significant quantities of material
- (D) : Can involve movement over significant distances
- **Not recommended, except for smallest fills**

4. Material

- Any available material of sufficient bearing strength
- Could vary from low activity clays to large boulders

5. Equipment

- Heavy steel drum rollers (> 10 ton). Light pedestrian type rollers cannot be used.
- Picks, shovels and wheel barrows

6. Construction

- Labour should only be used where the haul is less than 100 m and fill is less than 1 m high.
- Excavation of fill by pick and spade
- Loading into wheelbarrows
- Moving to new location

7. Maintenance

- Not applicable.

8. Production

- Estimate that a team of 12 labourers can load and haul 42 m^3 of loose soil over 100 m per day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria.

Appendix 3: LAYERS OF GRAVEL MATERIAL

1. Definition

- Pavement layers of selected gravel materials used as selected layers to bring subgrade support up to required structural standard, subbase or base course.

2. Application

- Selected layers are used mostly on higher standard roads where additional structural thickness is required. Not necessary on lower trafficked roads unless subgrade/earthwork materials are very poor (CBR < 15%).
- Subbase and base generally used on roads of any standard (subbase may be omitted on lightly trafficked roads where in situ materials are particularly good).

3. Advantages / Disadvantages

- A: If done using shuttering, may be slow but can give good results.
- A: Can create significant employment if used instead of plant.
- D: Usually too much material to be hauled using labour-intensive processes.
- D: Smooth finishing difficult to achieve without the use of conventional compaction equipment and graders.
- D: Needs very intense and good supervision to achieve standards similar to plant based construction.
- D: Team balancing critical to ensure that all operations (dumping, spreading, leveling, rolling) are carried out at the same rates.

4. Material

- Selected natural gravel.

5. Equipment

- Pedestrian plate vibratory compactor.
- Pedestrian steel drum roller (optional).
- Straight edge and guide rails.
- Wheelbarrows, shovels, ballast fork, rakes, brooms etc.

6. Construction

- Set up leveling tools and equipment (Guide rails, straightedge etc.)
- Place and spread the selected material using the leveling equipment.
- Check for levels and a undulations and do the necessary corrections.
- Screed to level of shuttering
- Use a pedestrian roller to apply even compaction effort and reduce level to lower shutter level.

7. Maintenance

- Not applicable – layer covered.

8. Production

- Depends mostly on rate of setting up shuttering. Highly variable.

Appendix 4: EMULSION TREATED BASE

1. Definition

- A compacted layer of aggregate/gravel treated with a small amount of bitumen emulsion.

2. Application

- Base course made with fresh aggregate or rehabilitation/upgrading of an existing aggregate base course.

3. Advantages / Disadvantages

- A: High bearing capacity.
- A: Good weather and traffic resistance for the interim period prior to the application of the seal.
- A: More flexible/accommodating than G1 and cement/lime stabilised gravel layers.
- A: Addition of emulsion acts as a compaction aid.
- A: No need to prime before surfacing.
- A: Base more resistant to potholing when surfacing fails.
- D: Requires sound and reasonably well graded aggregate/gravel (better than G5).

4. Material

- Sound aggregate/gravel of G1 – G4 classification.
- Stablemix grade Anionic 60 bitumen emulsion (60/40).
- Cement/lime if specified in design.
- Water.
- Binder solvent (such as “Tar Solve” diluted 1:4 with paraffin), etc.

5. Equipment

- Wheelbarrows, shovels, rakes, brooms, measuring cans, guide & bulking rails, etc. to suit job size.
- Transport for carting gravel/aggregate as necessary.
- 150/200 concrete mixer.
- Suitably sized (≈ 1 ton) tandem vibratory pedestrian roller/s as necessary depending job size.
- First aid kit and protective clothing.

6. Construction

- Fix guide and bulking rails of specified dimensions onto road.
- Measure off amounts of aggregate, bitumen emulsion and water (+ cement/lime if specified).
- Mix aggregate, bitumen emulsion and water in concrete mixer.
- Spread mix out between guide rails onto road to the top of the bulking rails and level off.
- Remove bulking rails.
- Compact layer with roller/s to specified thickness (lower guide rail height).
- Preferably cover with seal suitable to specific traffic conditions.

7. Maintenance

- Repair ravelling/cracks/potholes if/as necessary with similar material.

8. Production

- Estimate that a team of 14 trained labourers can do 140 m^2/day of 100 mm thickness.

9. References

- Labour-based methods and technologies for employment intensive construction work – a CIDB guide to best practice.
- Sabita manual 21: The design and use of emulsion treated bases.

Appendix 5: FOAMED BITUMEN GRAVEL LAYERS

1. Definition

- A compacted layer of gravel or recycled material pretreated with foamed bitumen. The gravel is pretreated through a batching plant and can remain in stockpile for long periods (± 3 months) prior to construction.

2. Application

- Base and subbase layers for heavy trafficked roads.

3. Advantages/Disadvantages

- A: Spreading, leveling and compaction of gravel layer can be done at a low mechanisation level by hand.
- A: Very durable layer which can be trafficked immediately.
- A: More flexible/accommodating than gravel stabilised layers.
- A: Material can be stockpiled for up to 6 months before use.
- A: No need to prime before surfacing.
- D: Foam treatment is done through a static batching plant. Large volumes are required to warrant establishment costs.
- D: Limited foaming batching plants available in Southern Africa.

4. Material

- Gravel G6 or better.
- Penetration grade bitumen.
- Lime/cement if specified in the design

5. Equipment

- Bitumen foam batching plant
- Transport for carting gravel and foamed treated gravel as necessary.
- Suitable sized (1 ton) tandem vibratory pedestrian roller.
- First aid kit and protective clothing

6. Construction

- Gravel is pretreated through the batching plant and stockpiled.
- Fix guide rails with bulking rails of specified dimensions onto road.
- Spread pretreated foamed gravel between the guide rails (allow for bulking)
- Remove bulking rails and compact layer with roller to specified thickness (lower guide rail height).

7. Maintenance

- Repair potholes if necessary with similar material or by using asphalt (hot or cold).

8. Production

- Estimate that a team of 10 labourers can do approximately 250m² of 100mm thickness.

9. References

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Horak E, Potgieter CJ and Hattingh J (1996) "Back to the future" empowered road construction. Urban Management, November 1996.

Jenkins KL, van de Ven, MFC and de Groot JLA (1999) *Characterisation of foamed bitumen*. Proceedings of the 7th conference on Asphalt Pavements of Southern Africa, Victoria Falls, Zimbabwe, August 1999.

Appendix 6: COMPOSITE EMULSION TREATED BASE

1. Definition

- A compacted layer of aggregate/gravel of which the top third is treated with a small amount of bitumen emulsion.

2. Application

- Base course made with fresh aggregate or rehabilitation/upgrading of an existing aggregate base course.

3. Advantages / Disadvantages

- A: Relatively high bearing capacity at lower cost than an emulsion treated base.
- A: Good weather and traffic resistance for the interim period prior to the application of the seal.
- A: More flexible/accommodating than G1 and cement/lime stabilised gravel layers.
- A: No need to prime base before surfacing
- D: Requires availability of bitumen emulsion and necessary mixing equipment.
- D: Requires sound and reasonably well graded aggregate/gravel (better than G5).

4. Material

- Sound aggregate/gravel of G1 – G4 classification.
- Stablemix grade Anionic 60 bitumen emulsion (60/40).
- Cement/lime if specified in design.
- Water.
- Binder solvent (such as "Tar Solve" diluted 1:4 with paraffin), etc.

5. Equipment

- Wheelbarrows, shovels, rakes, brooms, measuring cans, guide & bulking rails, etc. to suit job size.
- Transport for carting gravel/aggregate as necessary.
- 150/200 concrete mixer.
- Suitably sized (≈ 1 ton) tandem vibratory pedestrian roller/s as necessary depending job size.
- First aid kit and protective clothing.

6. Construction

- Fix guide rails of specified dimensions onto road (say for a layer of 100 mm thickness).
- Spread two-thirds (66 mm) of layer with the untreated gravel between the guide rails.
- Measure off amounts of aggregate, bitumen emulsion and water (+ cement/lime if specified).
- Mix aggregate, bitumen emulsion and water in concrete mixer.
- Add bulking rails & spread mix out on top of the untreated layer to top of bulking rails and level off.
- Remove bulking rails & compact layer with roller/s to specified thickness (lower guide rail height).
- Preferably cover with seal suitable to specific traffic conditions.

7. Maintenance

- Repair ravelling/cracks/potholes if/as necessary with similar material.

8. Production

- Estimate that a team of 14 trained labourers can do 140 m^2/day of 100 mm thickness.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria.

Appendix 7: WATER/DRYBOUND MACADAM BASE LAYER

1. Definition

- Pavement layer constructed where the voids in a large single-sized stone skeleton are filled using a fine sand.

2. Application

- Base layers for heavy trafficked roads.

3. Advantages / Disadvantages

- A: Spreading and levelling of stone aggregate and filler sand can be done by hand.
- D: Density requirements difficult to achieve without the use of heavy rollers.
- D: Smooth finishing without surface irregularities difficult to achieve.

4. Material

- Crushed single sized stones (nominal sizes either 26,5m or 37,5m or 53mm). The nominal stone size may be approximately one third of the layer thickness.
- Dry bound Macadam: Fine cohesion (PI-non-plastic) sand with a sand equivalent of not less than 35 (TMHI method B19) (No water required to place filler sand).
- Water bound Macadam: Fine slightly plastic sand (PI ≥ 6) with a sand equivalent of not less than 35 (TMHI method B14) (Water required to place filler sand).

5. Equipment

- Heavy steel drum rollers (> 10 ton). Should light pedestrian type rollers be used the required density for layers above 75mm thick will not be achieved which will compromise the structural capacity of the layer.
- Wheel barrows, shovels, ballast forks, rakes, brooms etc.

6. Construction

- *Water bound Macadam:* Spread the coarse aggregate to the required thickness (initially the layer is placed 30% thicker than the final layer to allow for compaction thickness loss) and levels using ballast forks and a straight edge.
  Use the roller, preferably a 12 ton steel wheel or drum-type roller to achieve aggregate orientation and correct local depression by working with the ballast forks. Rolling normally starts on the outer edge, which is supported either by the gravel shoulder of kerbing in a box-type construction or by wooden forms, until the outer par is stable and then compaction of the centre takes place.
  A thin layer (about 10mm) of dry natural plaster sand is spread evenly over the coarse aggregate by means of a stiff broom, and worked into the voids of the coarse aggregate. This action is repeated until no more sand penetrates into the voids.
  The surface of the layer is then thoroughly wetted and the heavy roller is used to compact the layer. Additional fine material and water is added to fill any further voids. Finally, when no further voids appear, the upper part of the layer is slushed to develop a dense mosaic. Any excess fines near the surface will be worked to the surface during this process.
  After the surface had dried, the excess fine material is swept away to expose the densely knit stone mosaic with the voids between the stones filled with compacted fine material.

- *Dry bound Macadam:* The process is identical to that of the water bound macadam layer, except that less water is used, as water is only used to slush the surface. The dry sand is vibrated with a plate vibrator or vibrating roller to penetrate the voids between the coarse aggregate. Regular brooming during this process is essential.

7. Maintenance

- The dominant failure mechanism on Macadam pavement is ravelling. Selection of a durable seal or surfacing type on the water / dry bound Macadam is of utmost importance. This bituminous slurry seals or single seals will not suffice.

8. Production

- Estimate that a team of 12 labourers can prepare 300m^2 of 150m thick water / dry bound Macadam prior to densification trimming and sweeping if material is supplied in stockpile on the road. Sound team balancing planning is necessary to optimize the production rates.
  The task rate is based on the following production rates:
  - 3 labourers can spread and level 15m^3 Macadam aggregate per day (100 m^2 / day)
  - 1 labourer can spread and level 7m^3 sand per day (100 m^2 / day)

Appendix 8: SLURRYBOUND MACADAM BASE LAYER

1. Definition

- Surfacing layer constructed where the voids in single-sized stone skeleton are filled using bituminous slurry.

2. Application

- Surfacing layer suitable for all traffic-conditions.

3. Advantages / Disadvantages

- A: This layer can be constructed using light pedestrian type rollers only.
- A: Layer thicknesses between 15mm to 50mm may be applied in accordance with the pavement design.
- D: Smooth finishing difficult to achieve without the use of patented finishing techniques.

4. Material

- Crushed single sized stones (nominal sizes either 13,2; 19mm or 26,5 mm). The nominal stone size must be approximately one third of the layer thickness.
- Crushed sand with a sand equivalent of not less than 35.
- Portland cement.
- Stablemix anionic 60 bitumen emulsion.

5. Equipment

- Pedestrian plate vibratory compactor.
- Pedestrian steel drum roller (optional).
- Straight edge and guide rails.
- Concrete mixer (optional)
- Motorized spinning beam (Patented technique / optional)
- Wheelbarrows, shovels, ballast fork, rakes, brooms etc.

6. Construction

- Set up leveling tools and equipment (Guide rails, straightedge etc.)
- Place and spread the single sized stone using the leveling equipment.
- Orientate the stone using a plate vibratory compactor.
- Check for levels and a undulations and do the necessary corrections.
- Mix the slurry to the designed mix specifications.
- Spread the slurry.
- Use a plate vibratory compactor to penetrate the slurry.
- Use leveling equipment and apply the finishing techniques.

7. Maintenance

- The maintenance on this surfacing-type will be similar to other bituminous surfacing types.

8. Production

- Estimate that a team of 10 laborers can construct a 200m² of 50mm thick slurry bound Macadam per day provided materials are supplied on the road. Sound team balancing planning is necessary to optimize the production rates. The task rate is based on the following production rate:
  - 1 laborer can spread and level $5m^3$ Macadam aggregate per day (100m² / day)
  - 2 laborers can mix and spread $2m^3$ slurry per day (100m² / day)
  - 2 laborers to penetrate the slurry and apply finishes technique.

Appendix 9: COMPOSITE MACADAM LAYER

1. Definition

- Pavement and surfacing layer constructed where the bottom two-third voids in a large single-sized stone skeleton are filled with sand and the top-third filled with a bituminous slurry.

2. Application

- Base and surface layer for lower trafficked roads.

3. Advantages / Disadvantages

- A: The composite layer is constructed in two stages namely the bottom two-third as for a water/dry bound Macadam and the top third like a slurry bound Macadam.
- A: The bottom two-thirds are constructed similar to a water or dry bound Macadam layer and will have the same advantages and disadvantages. The top third will be similar to a slurry bound Macadam surface.
- D: Level control is difficult on a composite Macadam layer.
- D: The construction process is slow relative to the other Macadam types and can become uneconomical.

4. Material

- *Bottom two thirds:* Crushed single sized stones (nominal sizes either 26.5m or 37.5m or 53mm). The nominal stone size may be approximately one third of the layer thickness.
  Dry bound Macadam: Fine cohesion (PI-non-plastic) sand with a sand equivalent of not less than 35 (THMI method B19) (No water required to place filler sand).
  Water bound Macadam: Fine slightly plastic sand (PI . 6) with a sand equivalent of not less than 35 (YHMI method B14) (Water required to place filler sand).
- *Top third:* Crushed single sized stones (nominal sizes either 13.2; 19mm or 26.5 mm) with the nominal stone size being approximately one third of the layer thickness, crushed sand with a sand equivalent of not less than 35, Portland cement and stablemix anionic 60 bitumen emulsion.

5. Equipment

- *Bottom two thirds:* Heavy steel drum rollers (> 10 ton). Should light pedestrian type rollers be used the required density for layers above 75mm thick will not be achieved which will compromise the structural capacity of the layer.
  Wheel barrows, shovels, ballast forks, rakes, brooms etc.
- *Top third:* Pedestrian plate vibratory compactor.
  Pedestrian steel drum roller (optional)
  Straight edge and guide rails.
  Concrete mixer (optional)
  Motorized spinning beam (Patented technique / optional)
  Wheelbarrows, shovels, ballast fork, rakes, brooms etc.

6. Construction

- *Bottom two thirds: If water bound*: Spread the coarse aggregate to the required thickness (initially the layer is placed 30% thicker than the final layer to allow for compaction thickness loss) and levels using ballast forks and a 3m straight edge.
  Use the roller, preferably a 12 ton steel wheel or drum-type roller to achieve aggregate orientation and correct local depressions by working with the ballast forks. Rolling normally starts on the outer edge, which is supported either by the gravel shoulder or kerbing in a box-type construction or by wooden forms, until the outer par is stable and then compaction of the centre takes place.
  A thin layer (about 10mm) of dry natural plaster sand is spread evenly over the coarse aggregate by means of a stiff broom, and worked into the voids of the coarse aggregate. This action is repeated until no more sand penetrates into the voids.
  The surface of the layer is then thoroughly wetted and the heavy roller is used to compact the layer. Additional fine material and water is added to fill any further voids. Finally, when no further voids appear, the upper part of the layer is slushed to develop a dense mosaic. Any excess fines near the surface will be worked to the surface during this process. After the surface has dried, the excess fine material is swept away to expose the densely knit stone mosaic with the voids between the stones filled with compacted fine material.
- *Bottom two thirds: If dry bound:* The process is identical to that of the water bound macadam layer, except that less water is used, as water is only used to slush the surface. The dry sand is vibrated with a plate vibrator or vibrating roller to penetrate the voids between the coarse aggregate. Regular brooming during this process is essential.
- *Top third:* Set up leveling tools and equipment (Guide rails, straightedge etc.)
  Place and spread the single sized stone using the leveling equipment.
  Orientate the stone using a plate vibratory compactor.
  Check for levels and a undulations and do the necessary corrections.
  Mix the slurry to the designed mix specifications.
  Spread the slurry.
  Use a plate vibratory compactor to penetrate the slurry.
  Use leveling equipment and apply the finishing techniques.

7. Maintenance

- The maintenance on this surfacing-type will be similar to other bituminous surfacing types.

Appendix 10: LIME TREATED/STABILISED GRAVEL BASE AND SUB-BASE

1. Definition

- A compacted layer of gravel treated with a nominal amount of lime.

2. Application

- Base and sub-base made with marginal quality gravel to achieve specified bearing capacity/water proofing.

3. Advantages / Disadvantages

- A: Allows use of marginal/high PI gravel – preferred for basic crystalline material.
- A: Lowers PI, improves workability, bearing capacity and water resistance of gravel.
- A: Low stabilisation crack forming potential.
- A: Works best with reasonably well graded gravel and materials with low grading modulus
- D: Traffic must be kept off until suitably sealed.
- D: Damage by traffic relatively time consuming to repair compared to natural gravel.

4. Material

- Sufficient quantity of gravel (preferably uniformly well graded and similar in quality).
- Lime in pockets.
- Water.

5. Equipment

- Wheelbarrows, shovels, rakes, measuring cans, guide & bulking rails to suit job size.
- Transport for carting gravel as necessary.
- Lime storing shed.
- 150/200 concrete mixer.
- Suitably sized (≈ 1 ton) tandem vibratory pedestrian roller/s as necessary depending job size.
- Plastic cover for stabilised area prior to compaction to inhibit loss of moisture.
- First aid kit and protective clothing.

6. Construction

- Fix guide and bulking rails of specified dimensions on to road.
- Measure off amounts of gravel, lime and water (as necessary for mixture to reach OMC).
- Mix gravel and lime to uniform mixture in concrete mixer.
- Add water if/as necessary to mixture in concrete mixer and mix to uniform damp (OMC) state.
- Transport mixture by wheelbarrow to guide railed site.
- Spread mix between guide rails to top of bulking rails and level off.
- Cover with plastic sheet to keep material at OMC.
- Remove bulking rails (do not walk on layer prior to compaction).
- Compact layer with roller/s to specified thickness (lower guide rail height).
- Keep traffic off until suitably sealed.

7. Maintenance

- Tack area affected with diluted emulsion (1:6/1:4).
- Repair ravelling/cracks/potholes if/as necessary with similar material or emulsion treated gravel.

8. Production

- Estimate that a team of 14 trained labourers can do 100 m^2/day of 100 mm thickness.

9. References

- See relevant references in Appendix 1.

Appendix 11: CEMENT TREATED / STABILISED GRAVEL BASE AND SUB-BASE

1. Definition

- A compacted layer of gravel treated with a nominal amount of cement.

2. Application

- Base and sub-base made with marginal quality gravel to achieve specified bearing capacity/water proofing.

3. Advantages / Disadvantages

- A: Allows use of marginal gravel but not recommended for basic crystalline rocks.
- A: Improves bearing capacity and water resistance of gravel.
- D: High propensity for the formation of closely spaced stabilisation cracks.
- D: Works best with reasonably well graded gravel.
- D: Traffic must be kept off until suitably sealed.
- D: Proper curing can be problematic especially with basic crystalline material.

4. Material

- Sufficient quantity of gravel (preferably uniformly well graded and similar in quality).
- Cement in pockets.
- Water.

5. Equipment

- Wheelbarrows, shovels, rakes, measuring cans, guide & bulking rails to suit job size.
- Transport for carting gravel as necessary.
- Cement storage facility.
- 150/200 concrete mixer.
- Suitably sized (≈ 1 ton) tandem vibratory pedestrian roller/s as necessary depending job size.
- Plastic cover for stabilised area prior to compaction to inhibit loss of moisture.
- First aid kit and protective clothing.

6. Construction

- Fix guide and bulking rails of specified dimensions onto road.
- Measure off amounts of gravel, cement and water (as necessary for mixture to reach OMC).
- Mix gravel and cement to uniform mixture in concrete mixer.
- Add water if/as necessary to mixture in concrete mixer and mix to uniform damp (OMC) state.
- Transport mixture by wheelbarrow to guide railed site.
- Spread mix between guide rails to top of bulking rails and level off.
- Remove bulking rails (do not walk on layer prior to compaction).
- Cover with plastic sheet to keep material at OMC.
- Compact layer with roller/s to specified thickness as soon as possible (lower guide rail height).
- Keep traffic off until suitably sealed.

7. Maintenance

- Tack area affected with diluted emulsion (1:6/1:4).
- Repair ravelling/cracks/potholes if/as necessary with similar material or emulsion treated gravel.

8. Production

- Estimate that a team of 14 trained labourers can do 100 m^2/day of 100 mm thickness.

9. References

- See relevant references in Appendix 1.

Appendix 12: CRUSHER-RUN SUB-BASE AND BASE (G2, G3)

1. Definition

- A compacted layer of graded crushed/natural aggregate.

2. Application

- High quality base course for medium to high traffic volume.

3. Advantages / Disadvantages

- A: High bearing capacity & good life expectancy.
- A: Inhibits crack reflection from (stabilised) supporting layers.
- A: Good riding quality.
- D: May require additional man-made aggregate if natural material is not completely suitable.
- D: requires precise construction to achieve density specification.
- D: Traffic must be kept off until suitably sealed.

4. Material

- Crusher-run to specification.
- Natural aggregate/material/fines as necessary
- Water.

5. Equipment

- Wheelbarrows, shovels, rakes, measuring cans, guide & bulking rails, etc. to suit job size.
- Transport for carting aggregate to site as necessary.
- Suitably sized (≈ 1 ton) tandem vibratory pedestrian roller/s as necessary depending job size.
- First aid kit and protective clothing.

6. Construction

- Fix guide and bulking rails of specified dimensions onto road.
- Measure off amounts of gravel and water (as necessary for mixture to reach OMC).
- Add water if/as necessary to mixture in concrete mixer and mix to uniform damp (OMC) state.
- Transport mixture by wheelbarrow to guide railed site.
- Spread mix between guide rails to top of bulking rails and level off.
- Remove bulking rails (do not walk on layer prior to compaction).
- Cover with plastic sheet to keep material at OMC.
- Compact layer with roller/s to specified thickness (lower guide rail height).
- Apply water as necessary.
- Broom off any excess fines (slurry) drawn from layer.
- Allow layer to dry out before sealing.
- Keep traffic off until suitably sealed.

7. Maintenance

- Repair ravelling/cracks/potholes if/as necessary with emulsion treated gravel.

8. Production

- Estimate that a team of 14 trained labourers can do 100 m^2/day of 100 mm thickness.

Appendix 13: CRUSHED STONE (G1) BASE

1. Definition

- A high density layer of graded crushed aggregate.

2. Application

- High quality base course for heavy duty service.

3. Advantages / Disadvantages

- A: Very high bearing capacity – can handle heaviest traffic loading.
- A: Inhibits crack reflection from (stabilised) supporting layers.
- A: Very good riding quality.
- A: Low water permeability/sensitivity.
- D: High specification man-made material.
- D: requires precise construction to achieve final density specification.
- D: Traffic must be kept off until suitably sealed.
- D: Requires low deflection support (< 0.5 mm) for heavy traffic loading.
- D: Low LIC potential.

4. Material

- Crushed stone to specification from reliable quarry.
- Water.

5. Equipment

- Wheelbarrows, shovels, brooms.
- Transport for carting aggregate to site as necessary.
- Watering truck.
- Motor grader.
- Suitably sized (12-17 ton) steel drum and pneumatic roller/s.
- Mechanised rotary broom + prime mover (manual brooms can be used).
- First aid kit and protective clothing.

6. Construction

- Prepare shoulders to form “box” within which crushed stone (aggregate) is to be placed.
- Stockpile aggregate onto road between shoulders at required spacing.
- Spread aggregate (at OMC) with grader between prepared shoulders to level.
- Do basic compaction to at least 85% of ARD (solid density) – no deformation under roller any more.
- Thoroughly water layer and do final slush compaction while continually watering layer.
- Broom slush drawn out of layer to side of road (wind-row).
- Stop slushing process when no more slush is drawn out of layer (water clears) and final density specification has been achieved (88% of ARD).
- Allow layer to dry out before sealing.
- Keep traffic off until suitably sealed.

7. Maintenance

- Repair ravelling/cracks/potholes if/as necessary with emulsion treated gravel.

8. Production

- Not truly LIC – expect 1000 to 1500 m^2/day with the necessary plant assistance.

Appendix 14: SAND SEAL

1. Definition

- A carpet of sand spread over a freshly sprayed bituminous binder.

2. Application

- When labour-intensive construction methods have to be used.
- First seal/reseal for relatively light traffic (< 1000 vpd, but has performed well on "provincial" roads).
- Temporary/construction deviations.
- When good quality aggregate is not available/too expensive.

3. Advantages / Disadvantages

- A: Relatively simple and inexpensive to construct depending on the availability of sand.
- A: Carpet thickness can easily be increased with successive applications.
- A: Maintenance is simple yet must be monitored attentively.
- A: Affords some protection to surface and other pavement layers.
- D: Has a relatively low bearing capacity/shear resistance.
- D: Skid resistance for high speed traffic problematic, depending climatic conditions.
- D: Attentive brooming back of sand over extended periods can be impractical and/or expensive.
- D: Requires an efficient motorised hand sprayer with controllable delivery.
- D: Requires a second seal after 2 years.

4. Material

- Sound, clean and dust free sand or crusher fines graded from 1 to 4 mm nominal size.
- Spray grade Cationic 60 bitumen emulsion.
- Water.
- Binder solvent (such as "Tar Solve" diluted 1:4 with paraffin).

5. Equipment

- Wheelbarrows, shovels, rakes, brooms, spray screens, measuring containers, etc. to suit size of job.
- Rotary screen if necessary to produce clean and dust free sand of required size.
- Transport for carting sand as necessary.
- Motorised hand binder sprayer + lance and reinforced paper for joints.
- Manually operated sand spreader.
- Light vibratory pedestrian roller/s as necessary depending on the job size.
- First aid kit.
- For larger projects – mechanised broom + LDV to broom back sand during retention period.
- Special device for lifting drums on to hand sprayer.

6. Construction

- Lightly broom surface prior to sealing to clean off any debris.
- Spray cationic emulsion @ 1.2 l/m^2.
- Spread sand over binder to a thickness that will blot binder effectively (@ ≈ 0.007 m^3/m^2).
- Lightly drag-broom sand to even it out.

- One pass compact sand with pedestrian roller/s.
- Add/broom sand on to binder-rich areas, to prevent “pick-up”, regularly!
- Open to traffic for 14 days and repeat process if required.

7. Maintenance

- Repeat process as necessary to increase seal thickness or to repair failures.

8. Production

- Estimate that a team of 14 trained labourers can do 3000 m^2/day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria

Appendix 15: SINGLE SEAL

1. Definition

- A single layer of stone chippings spread over a freshly sprated bituminous binder.

2. Application

- When labour-intensive construction methods have to be used.
- First seal on a newly constructed/prepared road/parking area and ETB base.
- Reseal action on an existing/old surfacing.
- Seal for a temporary road/detour during construction.

3. Advantages / Disadvantages

- A: High skid resistance.
- A: Very flexible/accommodating when properly maintained.
- A: Relatively long life expectancy when properly maintained.
- A: Relatively low cost to implement.
- D: Requires experience to design and construct properly.
- D: Requires efficient motorised hand sprayer with controllable delivery.
- D: Requires sound support/base to prevent punch-in by traffic.
- D: Needs attentive routine (preventative) maintenance to retain integrity & flexibility.

4. Material

- Sound, clean and dust free single sized crushed stone chippings (aggregate) of a prescribed size.
- Spray grade Cationic 60 bitumen emulsion.
- Stable grade Anionic 60 bitumen emulsion or inverted emulsion for prime.
- Water.
- Binder solvent (such as "Tar Solve" diluted 1:4 with paraffin), reinforced paper for joints, etc.

5. Equipment

- Wheelbarrows, shovels, rakes, brooms, spray screens, measuring cans, etc. to suit job size.
- Transport for carting chippings as necessary.
- Motorised hand binder sprayer + lance.
- Manually operated chip spreader.
- Light vibratory pedestrian roller/s as necessary depending job size.
- First aid kit and protective clothing.
- Special device for lifting drums onto sprayer.

6. Construction

- Lightly broom surface prior to sealing to clean off any debris.
- On an ETB, lightly spray surface with anionic Stablemix 60 emulsion diluted 1:8 @ 0.5 – 0.6 l/m^2, if "prime" is required.
- On natural gravel base, use an inverted emulsion prime @ 0.7 l/m^2.
- Spray cationic spray grade 60 emulsion tack coat @ 0.6 - 0.7 l/m^2 (retain any additional binder for penetration coat).
- Spread chippings evenly shoulder to shoulder on to fresh binder.
- Lightly compact (2 passes) chippings to imbed them into tack coat.

- Spray rest of binder (cationic spry grade 60 bitumen emulsion) as a penetration coat.
- Blot with dust free crusher fines for early traffic accommodation, if so desired.
- Back-chip where binder is not covered or flushing.

7. Maintenance

- Seal open cracks as necessary.
- Rejuvenate binder with diluted bitumen emulsion spray as necessary (i.e. 8 to 10 years).
- Repair potholes if necessary.
- Reseal with slurry seal as necessary first time round & with single seal second time round.

8. Production

- Estimate that a team of 14 trained labourers can do 3000 m^2/day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria

Appendix 16: CAPE SEAL

1. Definition

- A layer of single sized crushed stone chippings spread over a freshly sprayed bituminous binder and filled with a layer of slurry.

2. Application

- When labour-intensive construction methods have to be used.
- First seal or reseal on a newly constructed/prepared road/parking area/”quiet” zones.

3. Advantages / Disadvantages

- A: Durable seal with good bearing capacity and tyre contact stress transfer.
- A: Very flexible/accommodating.
- A: LIC friendly.
- D: Relatively expensive because of high binder content.
- D: Requires an efficient motorised hand sprayer with controllable delivery.

4. Material

- Sound, clean and dust free single sized stone chippings (aggregate) of the prescribed size.
- Sound, clean and graded crusher dust suitable for slurry (graded < 6,7 mm).
- Spray grade cationic 60 bitumen emulsion (65/35) or inverted emulsion prime for tack coat.
- Stablemix grade anionic 60 bitumen emulsion (60/40) for slurry.
- Cement as prescribed.
- Water.
- Binder solvent (such as “Tar Solve” diluted 1:4 with paraffin), reinforced paper for joints, etc.

5. Equipment

- Wheelbarrows, shovels, measuring cans, brooms, squeegees, spray screens, etc. to suit job size.
- Transport for carting chippings and sand as necessary.
- Rotary screen if necessary to produce clean and dust free sand of required size, if required.
- Motorised hand binder sprayer + lance.
- Manually operated chip spreader
- Light vibratory pedestrian roller/s as necessary depending job size.
- Concrete mixer with which to mix slurry, to suit job size.
- First aid kit and protective clothing.
- Special device for lifting drums on to sprayer.

6. Construction

- Lightly broom surface prior to sealing to clean off any debris.
- On and ETB, lightly spray surface with anionic Stablemix 60 emulsion diluted 1:8 @ 0.5 – 0.6 l/m^2, if “prime” is required.
- On natural gravel base, use an inverted emulsion prime @ 0.7 l/ m^2 and allow to cure.
- Spray cationic spray grade 60 emulsion tack coat @ 0.6 – 0.7 l/m^2 (spray any remainder as a penetration spray onto chippings).

- Spread chippings evenly shoulder to shoulder onto surface (0.006 – 0.007 m^3/m^2 for 13 mm chippings).
- Lightly compact (2 passes) chippings to imbed them into binder.
- Mix slurry @ 230 – 260 litres of anionic Stablemix 60 emulsion + 235 litres of water per m^3 of crusher dust.
- Spread slurry evenly onto layer of chippings and squeegee (broom) the slurry into the voids between the chippings and strike of the slurry from the top of the chippings.
- Lightly compact seal to "knit" it.

7. Maintenance

- Seal open cracks as necessary.
- Repair seal failures if/as necessary.
- Reseal with single seal or slurry seal as necessary.

8. Production

- Estimate that a team of 14 trained labourers can do 2000 m^2/day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria

Appendix 17: DOUBLE SEAL

1. Definition

- Two layers of stone chippings spread over a freshly sprayed bituminous binder in two consecutive applications..

2. Application

- First seal on a newly constructed/prepared road.

3. Advantages / Disadvantages

- A: durable seal with high bearing capacity and tyre contact stress transfer.
- A: High skid resistance & good protection of surface and other pavement layers.
- A: Very flexible/accommodating.
- D: Requires good know-how and attention to design and construct properly.
- D: Needs attentive routine maintenance/binder rejuvenation to retain integrity and flexibility.
- D: Requires efficient motorised hand sprayer with controllable delivery.

4. Material

- Sound, clean and dust free single sized crushed stone chippings (aggregate) of the prescribed sizes.
- Spray grade Cationic 60 bitumen emulsion binder.
- Stable grade Anionic 60 bitumen emulsion or inverted emulsion for prime.
- Water.
- Binder solvent (such as "Tar Solve" diluted 1:4 with paraffin), reinforced paper for joints, etc.

5. Equipment

- Wheelbarrows, shovels, rakes, brooms, spray screens, etc. to suit job size.
- Transport for carting chippings as necessary.
- Motorised hand binder sprayer + lance.
- Manually operated chip spreader
- Light vibratory pedestrian roller/s as necessary depending job size.
- First aid kit and protective clothing.
- For large projects: mechanised broom + LDV to rid surface of lose chippings on completion.
- Special device for lifting drums onto sprayer.

6. Construction

- Lightly broom surface prior to sealing to remove any debris.
- On ETB, lightly spray surface with anionic stablemix 60 emulsion diluted 1:8 @ 0.5 – 0.6 l/m^2, if "prime" is required.
- On natural gravel base, use an inverted emulsion prime @ 0.7 l/m^2.
- Spray cationic spray grade 60emulsion tack coat @ 0.6 - 0.7 l/m^2.
- Spread larger sized chippings evenly shoulder to shoulder onto fresh binder.
- Lightly compact (2 passes) chippings to imbed them into binder.
- Spray remainder of binder as a penetration layer onto first layer of chippings.
- Spread 1 layer of smaller sized chippings evenly onto first layer of chippings.
- Lightly compact (2 passes) to imbed chippings into binder and "knit" the double seal.

- Apply light spray of cationic spray grade 60 emulsion diluted 50:50 with water onto seal, if so designed/desired.
- Broom as necessary to remove lose chippings and re-roll the surface before opening to traffic.
- Blot with crusher dust for early traffic accommodation, if needed.

7. Maintenance

- Seal open cracks and repair seal failures if/as necessary.
- Rejuvenate binder with diluted bitumen emulsion spray as necessary.
- Reseal with slurry seal first time round (i.e. after 12 to 14 years).
- Reseal with single seal second time round (i.e. after 10 to 12 years).

8. Production

- Estimate that a team of 14 trained labourers can do 1500 m^2/day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria

Appendix 18: COLD GRADED AGGREGATE PENETRATION SEAL (Modified "Otta" Seal)

1. Definition

- A carpet of graded surfacing aggregate spread over a freshly sprayed bituminous binder.

2. Application

- First seal/reseal on a newly constructed/prepared road/parking area.

3. Advantages / Disadvantages

- A: Good bearing capacity and tyre contact stress transfer.
- A: Medium skid resistance & good protection of surface and other pavement layers.
- A: Flexible and accommodating.
- A: Relatively long life expectancy.
- D: Relatively expensive seal because of high binder contents.
- D: Requires an efficient motorised hand sprayer with controllable delivery.

4. Material

- Sound and clean "low-fines" graded surfacing aggregate (0,075 mm – 9,5 mm).
- Stablemix grade Anionic 60 bitumen emulsion.
- Stablemix grade Anionic 60 bitumen emulsion or inverted emulsion for prime.
- Water.
- Binder solvent (such as "Tar Solve" diluted 1:4 with paraffin), reinforced paper for joints, plastic sheeting, etc.

5. Equipment

- Wheelbarrows, shovels, rakes, brooms, spray screens, measuring cans, etc. to suit job size.
- Transport for carting aggregate as necessary.
- Motorised hand binder sprayer + lance.
- Manually operated aggregate spreader.
- Light vibratory pedestrian roller/s as necessary depending job size.
- First aid kit and protective clothing.
- Special device for lifting drums on to sprayer.

6. Construction

- Lightly broom surface prior to sealing to clean off any lose material/debris.
- On ETB, lightly "prime" surface with 1:8 diluted Anionic stable grade emulsion @ 0.5 – 0.6 l/m^2, if necessary.
- On natural gravel base, use an inverted emulsion prime @ 0.7 l/m^2.
- Spray Anionic stablemix 60 emulsion tack coat @ 0.6 - 0.7 l/m^2 (remainder of binder applied as penetration spray).
- Spread aggregate blanket evenly over freshly applied binder tack coat @ ≈ 0.01 m^3/m^2.
- Apply remainder of binder as penetration spray.
- Apply light compaction to seat and knit the seal.

7. Maintenance

- Seal open cracks as necessary.
- Rejuvenate binder with diluted bitumen emulsion spray as necessary.
- Repair seal failures if/as necessary.
- Reseal with slurry seal first time round (8-12 years) and single seal second time round (8-10 years).

8. Production

- Estimate that a team of 14 trained labourers can do 3000 m^2/day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria

Appendix 19: OTTA SEAL (Spray-tanker applied hot binder)

1. Definition

- A carpet of graded aggregate spread over a freshly sprayed hot bituminous binder.

2. Application

- First seal/reseal on a newly constructed/prepared road/parking area.

3. Advantages / Disadvantages

- A: Durable surface due to high binder content and high stone application rate.
- A: Good protection of surface and other pavement layers.
- A: Flexible and accommodating.
- No priming of base required prior to sealing.
- D: Requires hot binder sprayer.
- D: Relatively expensive seal because of high binder content.
- D: Screening of aggregate from natural material is expensive.
- D: Sensitive to early traffic damage and requires after care.

4. Material

- Sound and clean "low-fines" graded surfacing aggregate as specified in design (3 grading types).
- Bituminous binder as specified (MC 3000,150/200 pen cutback with kerosene or Gravseal. Depending on traffic and aggregate grading)
- Water.
- Binder solvent (such as "Tar Solve" diluted 1:4 with paraffin), reinforced paper for joints, plastic sheeting, etc.

5. Equipment

- Wheelbarrows, shovels, rakes, rotary broom, spray screens, measuring cans, etc. to suit job size.
- Transport for carting aggregate as necessary.
- Hot binder sprayer and heavy pneumatic roller (27/30 ton).or pedestrian roller depending.
- Manually operated aggregate spreader.
- Reinforced paper for spray joints and first aid kit and protective clothing.

6. Construction

- Lightly broom surface prior to sealing to remove any loose material/debris.
- Lightly dampen the gravel base with water before spraying hot binder.
- Spray hot cutback binder tack coat as specified with a bitumen distributor.
- Allow binder to penetrate for 20 minutes before spreading aggregates.
- Spread aggregate blanket evenly over the freshly applied binder tack coat as designed ($\approx 0.01\ m^3/m^2$).
- Apply pedestrian roller/heavy pneumatic roller compaction to seat and knit the seal.
- Regularly broom back aggregate surfacing for up to two weeks after construction until it has settled down.

7. Maintenance

- Rejuvenate binder with diluted bitumen emulsion spray as necessary.
- Repair seal failures if/as necessary.
- Reseal with slurry seal first time round (8-12 years) and single seal Otta seal second time round (8-10 years).

8. Production

- Hand labour + hand sprayers: Estimate that a team of 14 trained labourers can do 500 - 600 m^2/day.
- Bitumen distributor + manual chip spreaders: Estimate that team of 60 labourers can do 5500 m^2/day.

9. References

- Refer to the "Design and Construction of Otta Seals" Guideline #1, Roads department, Republic of Botswana.
- Refer to paper by D Pagel and T R Distin entitled "Construction of graded crushed stone seals using a manually operated chip spreader" presented at the T^2 Conference In Pietermaritzburg in 2005.

Appendix 20: SLURRY SEAL

1. Definition

- A mixture of crusher sand and bitumen emulsion spread over the road surface.

2. Application

- When labour-intensive construction methods have to be used.
- Ideal for resealing existing aged seals for relatively light traffic (< 1000 vpd)/parking areas). Has also performed well on “provincial” low volume roads.
- Temporary/construction deviations/”quiet” zones.
- For rut filling or as a texture correction before resealing.

3. Advantages / Disadvantages

- A: Relatively simple and inexpensive to construct depending on the availability of crusher dust.
- A: Carpet thickness can easily be increased with successive applications.
- A: Good micro texture for urban roads where vehicle speeds are low.
- A: Seals aged surfaces and prevents ingress of water into the underlying pavement layers.
- D: Vulnerable to reflective cracking if placed on a week substrate with high deflections.
- D: Skid resistance for high speed traffic problematic in wet weather conditions.

4. Material

- Sound, clean crusher dust of specified grading.
- Stablemix grade Anionic 60 emulsion.
- Cement.
- Water.
- Binder solvent (such as “Tar Solve” diluted 1:4 with paraffin).

5. Equipment

- Wheelbarrows, shovels, brooms, measuring cans, squeegees, etc. to suit size of job.
- Rotary screen if necessary to produce clean and dust free sand of required size.
- Transport for carting the crusher dust as necessary.
- Concrete mixer for mixing slurry, to suit job size.
- Hessian burlap.
- First aid kit and protective clothing.

6. Construction

- Lightly broom surface prior to sealing to remove any debris.
- Spread slurry evenly over damp road surface to a minimum thickness of 8 mm.
- Drag a hessian burlap over the fresh slurry to provide a smooth finish.

7. Maintenance

- Repeat process as necessary to increase seal thickness (or to repair failures) only after seal has dried out sufficiently and/or taken traffic for a period.
- Seal open cracks and reseal surfacing with slurry, penetration or single seal as necessary.

8. Production

- Estimate that a team of 14 trained labourers can do 800 m^2/day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria

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Appendix 21: HOTMIX ASPHALT SURFACING (with hot bituminous binder)

1. Definition

- A mixture of graded aggregate and hot bitumen paved over the road surface.

2. Application

- As a surfacing or resurfacing on a newly constructed/prepared heavily trafficked roads and parking area.
- Areas where there is high traffic turning actions or heavy stationary traffic (eg intersections and bus stops).

3. Advantages / Disadvantages

- A: Excellent riding quality with good structural capacity and tyre contact stress transfer.
- A: Product quality is well controlled during manufacture.
- A: Can be opened to traffic as soon as it has cooled down.
- A: Long service life which requires low maintenance.
- D: Requires know-how to design and specialised plant for controlled mixing (low LIC potential).
- D: Construction cost higher than that of other bituminous surfacings.
- D: Haulage distance limited from central mixing plant.
- D: Hand laying slow – loss of temperature affects final density attainable.

4. Material

- Asphalt plant within 100 km of site.
- Diluted anionic stablemix 60 bitumen emulsion for tack coat.
- Binder solvent (such as “Tar Solve” diluted 1:4 with paraffin).

5. Equipment

- Asphalt paver preferable but can be laid by hand.
- Trucks to haul asphalt from asphalt plant and feed paver on continuous basis when paving.
- Motorised hand sprayer for spraying tack coat.
- Battens, screeds, shovels and rakes for spreading hotmix asphalt.
- Pedestrian vibratory roller/s.
- Asphalt edge cutter/trimmer, side forms and screed bars, wheel barrows.
- First aid kit and protective clothing.

6. Construction

- Establish guide line/system as required.
- Lightly broom existing surface or base prior to paving.
- If paving on a crushed stone, natural gravel or cement/lime treated base, prime with an inverted emulsion tack coat @ 0.6 - 0.7 l/m^2.
- If paving on an existing bituminous layer spray an anionic stablemix 60 bitumen emulsion diluted 50:50 with water as a tack coat.
- Lay asphalt by hand using side forms and screed bars, according to thickness specification.
- Compact asphalt immediately by rolling to specified density.
- Cut/trim edges of asphalt as necessary.

- Keep asphalt warm by covering the stockpile with a tarpaulin.

7. Maintenance

- Seal open cracks as necessary.
- Repair asphalt failures with hot or cold asphalt depending job size if/as necessary.
- Reseal first time round (8–12 years) with single seal – may require pre-treatment, depending porosity.

8. Production

- Can be hand laid but not hand mixed.

9. References

- Refer to the manual on hand-laid hotmix asphalt published by Much Asphalt, April 2002.

Appendix 22: ASPHALT SURFACING (COLD) (WITH BITUMINOUS EMULSION)

1. Definition

- A mixture of graded aggregate and emulsion paved over the road surface.

2. Application

- As the first seal or reseal on a newly constructed/prepared medium trafficked road and parking areas.
- For areas where there is high traffic turning actions (eg intersections).

3. Advantages / Disadvantages

- A: Good riding quality with adequate bearing capacity and tyre contact stress transfer.
- A: Long service life expectancy.
- A: Product quality well controlled during manufacture.
- D: Requires know-how to design and construct properly.
- D: Sensitive to early traffic damage after construction until emulsion has cured.
- D: Material costs are higher than hotmix asphalt but easier to place by hand.

4. Material

- Sound and clean low-fines crushed aggregate of the prescribed grading (0,075 – 9,5 mm).
- Mix grade Cationic premix grade 65 bitumen emulsion.
- Stablemix grade 60 Anionic bitumen emulsion for tack coat.
- Water.
- Binder solvent (such as "Tar Solve" diluted 1:4 with paraffin), seal joint paper, etc.

5. Equipment

- Wheelbarrows, shovels, brooms, spray screens, guide rails, screed bars, steel squeegees etc. (no brooms).
- Transport for carting chippings as necessary.
- 150/200 concrete mixer.
- Light vibratory pedestrian roller/s as necessary depending job size.
- First aid kit and protective clothing.

6. Construction

- Lightly broom surface prior to sealing to remove any debris.
- Apply anionic stablemix 60 bitumen emulsion diluted tack coat diluted 50:50 with water @ 0.4 – 0.5 l/m^2 by hand sprayer.
- Mix the correct proportions of aggregate in a concrete mixer with 124 litres of cationic premix grade 65 emulsion per m^3 of aggregate.
- Add small amounts of diesel to the mix to prevent lumps of fines forming.
- Spread & level asphalt with steel squeegees and screed bars between guide rails (≈ 19 mm deep).

7. Maintenance

- Seal open cracks as necessary.
- Repair seal/asphalt failures with asphalt if/as necessary.

- Reseal first time round (8 – 12 years) with fog spray + slurry seal.

8. Production

- Estimate that a team of 14 trained labourers can do 1000 m^2/day.

9. References

- CIDB (2005). An overview of labour-based technologies and methods in employment-intensive works. CIDB, Pretoria

Appendix 23: SLURRYBOUND MACADAM SURFACE LAYER

1. Definition

- Surfacing layer constructed where the voids in the single-sized stone skeleton are filled using bituminous slurry.

2. Application

- Surfacing layer suitable for low speed traffic-conditions.

3. Advantages / Disadvantages

- A: This layer can be constructed using light pedestrian type rollers only.
- A: Layer thicknesses between 15mm to 50mm may be applied in accordance with the pavement design.
- D: Smooth finishing difficult to achieve without the use of patented finishing techniques.

4. Material

- Crushed single sized stones (nominal sizes either 13.2; 19mm or 26.5 mm). The nominal stone size must be approximately one third of the layer thickness.
- Crushed sand with a sand equivalent of not less than 35.
- Portland cement.
- Anionic stablemix 60 bitumen emulsion.

5. Equipment

- Pedestrian plate vibratory compactor.
- Pedestrian steel drum roller (optional).
- Straight edge and guide rails.
- Concrete mixer (optional)
- Motorized spinning beam (Patented technique / optional)
- Wheelbarrows, shovels, ballast fork, rakes, brooms etc.

6. Construction

- Set up leveling tools and equipment (Guide rails, straightedge etc.)
- Place and spread the single sized stone using the leveling equipment.
- Orientate the stone using a plate vibratory compactor.
- Check for levels and a undulations and do the necessary corrections.
- Mix the slurry to the designed mix specifications.
- Spread the slurry.
- Use a plate vibratory compactor to penetrate the slurry.
- Use leveling equipment and apply the finishing techniques.

7. Maintenance

- The maintenance on this surfacing-type will be similar to other bituminous surfacing types.

8. Production

- Estimate that a team of 10 laborers can construct a 200m² of 50mm thick slurry bound Macadam per day provided materials are supplied on the road. Sound team balancing planning is necessary to optimize the production rates. The task rate is based on the following production rate:
  - 1 laborer can spread and level $5m^3$ Macadam aggregate per day (100m² / day)
  - laborers can mix and spread $2m^3$ slurry per day (100m² / day)
  - 2 laborers to penetrate the slurry and apply finish.

Appendix 24: ULTRA-THIN REINFORCED CONCRETE PAVEMENTS (UTRCP)

1. Definition

- A layer of concrete, 50mm thick and continuously reinforced with a reference 193 welded wire mesh.

2. Application

- Surfacing of a new road or the rehabilitation/upgrading of an existing roads/streets.
- Can be used for all traffic and road classes from low-volume township streets to inlays, to "provincial" roads where typical traffic volumes are below 2 500 vehicles per day with less than 10% heavy vehicles.
- Areas of steep grades and stop/start heavy traffic.
- Areas with limited maintenance capacity.

3. Advantages / Disadvantages

- A: Lower whole life cost for comparable design.
- A: Does not rut, shove or pothole.
- A: More durable - reduced maintenance.
- A: Labour friendly and therefore suitable for labour-intensive construction (investment in equipment fairly low).
- A: Skills acquired are not limited to road construction but are transferable to the wider building and construction industry
- A: Good performance in difficult areas where heavy loads and stop-start traffic are common
- A: Ideal for upgrading of existing deteriorated roads by overlaying.
- A: Possible reduced layer works – reduces amount of work to be carried out by plant which can result in reduced contract period and costs.
- A: Environmental benefits by utilising bottom dump ash and fly ash as aggregate
- A: Requires less lighting energy where streetlights are provided
- A: Low maintenance due to minimal joints
- A: More flexible/accommodating than conventional concrete
- D: Installation of new and relocation of existing service, as well as access to existing service could be a problem.
- D: Possibly increased initial cost.
- D: Attention to tolerances in construction of support layer and placing of mesh due to thinness of concrete.
- D: Care required to ensure proper curing.
- D: Some concreting skills needed.

4. Material

- Concrete sand complying with SANS.
- Concrete stone complying with SANS. The stone size should not exceed 9mm.
- Alternative to concrete stone is the use of screened bottom dump ash and fly ash.
- 42,5N Cem1 or 11 cement complying with SANS 50197
- Water.
- Welded wire mesh reinforcing reference 193 with required stools.
- Curing compound or plastic sheeting for curing.

5. Equipment

- Concrete mixer/s. The size and number will be determined by proposed production programme
- Wheel barrows, shovels, steel squeegees, etc. to suit size of job.
- Transport for moving concrete from mixer to placing area. This can be by wheelbarrow, dumpers etc.

6. **Steel side forms/shutters.**

- Equipment for compaction of the concrete. This will generally consist of a vibrating screed beam or truss.
- Movable bridge to prevent walking on mesh when placing and screeding concrete.
- Bass broom to provide texture.
- Saw for cutting longitudinal and construction joints.
- Equipment for sealing joints.
- Protective tenting where necessary.

7. **Construction**

- Set up side forms/shutters to correct tolerances on prepared support layer.
- Treat support layer with 1:8 diluted emulsion.
- Place wire mesh reinforcement prior to placing concrete.
- Batch, mix and transport concrete to placing area.
- Spread concrete evenly between shutters using steel squeegees.
- Compact concrete with vibrating beam.
- Once concrete is compacted, use a bull float to achieve required surface regularity, if required.
- Once concrete has set sufficiently broom surface transversely to provide texture.
- Apply cover with plastic sheeting to cure concrete.
- Saw joints where required.
- Seal joints where required.

8. **Maintenance**

- Seal large cracks, repair pop-ups if/as necessary with similar material to specification
- Reseal joints when and if sealant fails.

9. **Production**

- Estimated that a team of 20-25 labourers can produce 400 – 500 m²/day.

10. **References**

- CSIR (November 2007). Procedure for the construction of a 50 mm thick continuously reinforced concrete pavement (50 mm CRCP). CSIR, Pretoria

Appendix 25: CONVENTIONAL CONCRETE

1. Definition

- A layer of concrete laid on the subgrade or with a subbase depending on traffic. The concrete is both the wearing surface and main structural element in the pavement. The concrete pavement can be either jointed unreinforced or continuously reinforced depending on circumstances.

2. Application

- When labour-intensive construction methods have to be used.
- Can be used for all traffic and road classes from low-volume township streets to inlays and/or overlays on freeways.
- Areas of steep grades and stop/start heavy traffic.
- Areas where maintenance is unlikely or desirable.

3. Advantages / Disadvantages

- A: Lower whole life cost for comparable design
- A: Does not rut, shove or pothole
- A: Reduced maintenance
- A: Very low maintenance costs
- A: Labour friendly and therefore suitable for labour-intensive construction
- A: Skills acquired are not limited to road construction but are transferable to the wider building and construction industry
- A: Better performance in difficult areas where heavy loads and stop-start traffic are common
- A: Existing subgrade and alignment can be used
- A: Ideal for upgrading existing deteriorated roads by overlaying
- A: Can reduce stormwater reticulation needed
- A: Only simple inexpensive equipment needed
- A: Uses local materials
- A: Requires less lighting energy where streetlights are provided
- D: Possibly increased initial cost
- D: Increased material transport costs in remote areas
- D: Cracking potential during construction
- D: Some concrete skills needed

4. Material

- Concrete sand complying with SANS.
- Concrete stone complying with SANS. The stone size should not exceed a quarter of the slab thickness.
- Common cement complying with SANS 50197
- Water.
- Reinforcement where required. This may be in the form of weldmesh or conventional reinforcing bars
- Load transfer devices such as dowels and tiebars where required.
- Curing compound or plastic sheeting for curing.
- Side forms/shutters. These can be either timber or steel depending on the size of the project and the number of re-uses required.

3. Equipment

- Concrete mixer. The size will be determined by proposed production
- Wheel barrows, shovels, rakes, etc. to suit size of job.
- Transport for moving concrete from mixer to placing area. This can be by wheelbarrow, dumper, mixer trucks or tippers.
- Equipment for compaction of the concrete. This will generally consist of a poker vibrator for the edges and a vibrating screed beam or truss.
- Scraping straightedge and or bullfloat.
- Hessian or burlap to provide microtexture.
- Broom or tining rake to provide macrotexture.
- Equipment for spraying the curing compound where used.
- Saw for cutting contraction joints where used or a T-beam and plastic sheeting for wet forming of contraction joints.
- Protective tenting where necessary.

6. Construction

- Set up forms to correct tolerances.
- Place reinforcement and or dowels and tiebars
- Wet subgrade/subbase surface prior to placing concrete.
- Batch, mix and transport concrete to placing area.
- Spread concrete with even surcharge.
- Compact concrete. Vibrating beam is adequate up to 150 mm in thickness but poker must be used along joints. Poker and beam are required over whole area where thickness exceeds 150 mm.
- Once concrete is compacted, use straightedge and or bullfloat to achieve required surface regularity.
- Once concrete has stiffened slightly, drag hessian/burlap longitudinally to provide microtexture.
- Broom or tine surface transversely to provide macrotexture.
- Use t-beam to wet-form contraction joints if appropriate
- Apply curing compound or plastic sheeting to cure concrete.
- Saw contraction joints where required.
- Seal joints where required.

7. Maintenance

- Replace cracked panels where necessary
- Reseal joints when sealant fails.

8. Production

- Estimate that a team of 20 labourers can place 500m2/day at 180 mm thickness.

9. References

- Low-volume Concrete Roads.
- Concrete Intersections.

Appendix 26: CONCRETE BLOCK PAVING

1. Definition

- A course of interlocking or rectangular concrete blocks placed on a suitable base course and bedded and jointed with sand. The blocks can either be purchased or manufactured for the purpose using local labour.

2. Application

- Surfacing layer for all categories of road.

3. Advantages/Disadvantages

- A: Can use labour to manufacture blocks
- A: Laying/placing done by hand.
- A: Easy maintenance – remove, patch and replace.
- A: Fully specified by SABS (1058)
- D: Relatively slow construction.
- D: Can be costly (purchase/manufacture of blocks.

4. Material

- Suitable concrete
- Aggregate, sand and cement
- Bedding sand

5. Equipment

- Block casting equipment
- Transport for carting blocks and sand as necessary.
- Vibrating plate compactor.
- Spades, levels, hammers, brushes
- First aid kit and protective clothing

6. Construction

- Concrete edge beams and intermediate beams are placed on the prepared base course.
- Bedding sand is placed on the base course between the beams to a depth of 25 mm (± 5mm).
- Blocks are laid in the patterns shown on the Drawings.
- The blocks are compacted by two passes of the vibrating plate compactor.
- Jointing sand is brushed into the joints between blocks and surplus sand broomed off.
- Two further passes of the compactor are applied.

7. Maintenance

- Repair depressions, broken blocks or other failures by removing blocks, patching damaged base (and or underlying layers) and replacing blocks. New blocks may need to be used if they have been broken.

8. Production

- Estimate that a team of 10 labourers can lay approximately 150 to 200m² of blocks per day/task.

9. References

- Committee of Urban Road Authorities (CUTA). 1987. **Structural design of segmental pavements for southern Africa.** Pretoria: Department of Transport. (Urban Transport Guidelines; Draft UTG 2).

Appendix 27: STANDARD FORMS OF CONTRACT USED IN SOUTH AFRICA

Standard form of contract	Location for items covered by the scope of work	Names of the Parties to a Contract
GCC 1990, COLTO 1997, FIDIC Short Form of Contract	Specifications	Employer Contractor
FIDIC Conditions of Contract for Construction ("Red Book")	Specification and schedule	Employer Contractor
NEC Engineering and Construction Contract and Engineering and Construction Short Contract	Works Information	Employer Contractor
JBCC 2000 Principal Building Agreement , Minor Works Agreement	Schedule	Employer Contractor
NEC - The Professional Services Contract	Scope	Employer Consultant
CIDB Standard Services Contract	Scope of Work	Employer Service Provider
SAACE Form of Agreement for Consulting Services	Scope of Services	Client Consultant
GCC 2004	Scope of Work	Employer Contractor

Note:

The Engineering Council of South Africa have issued in government gazette No 24938, dated 28 February 2003, a document entitled: Guideline Scope of Services and Tariff of Fees for Persons Registered in terms of the Engineering Profession Act, 2000, (Act No. 46 of 2000). This document which provides a "guideline scope of service" and a "guideline tariff of fees" repeals Government Notice R 1113 of June 1982.

This document can be referenced in the scope of work and the pricing instructions. It uses the terms "client" and "consulting engineer". 26

Appendix 28: Community based road maintenance programmes

“Lengthman” system

The examples of community based road maintenance programmes described below are based on the “lengthman” approach to road maintenance

The system is based on the appointment of a 'lengthman' on a contract basis to maintain a section of road. He is provided with basic hand tools and supervised once a month by an overseer.

To reduce transport and accommodation costs a person living adjacent to the road is usually appointed as the 'lengthman'. The length of each individual's section is dependent on local conditions and is normally between 1,5 and 2 km. Payment is based on a 12 day working month which allows the contractor time to attend to other interests during the remainder of the month. The contractor can be replaced if he consistently performs badly

Examples of community based road maintenance systems

KZN Department of Roads and Transport – Zibambele

The Zibambele Road Maintenance Contract System is a routine road maintenance programme using labour-intensive methods. It encourages flexible working hours thus allowing households adequate time to deploy their labour on other activities.

A Zibambele household will maintain the road drainage system, ensure good roadside visibility, maintain the road surface in good condition, and clear the road verges of litter and noxious weeds.

- The length of the road allocated to each household depends on the difficulty of the terrain, the more difficult the terrain the shorter the length of road.
- The maintenance need of the road is based on a maximum of sixty working hours per month.
- A Zibambele contract is awarded for twelve months and is renewed annually.
- Contracts target the poorest of the poor, who are identified and selected by their own community.
- Zibambele focuses on woman headed households who make up the majority of the poorest families.
- Training includes technical skills on road maintenance and social development and life skills.
- Support services include assisting contractors to, obtain identity documents, open bank accounts, organize themselves collectively into credit unions, and invest savings in other productive activities.

In order to facilitate the cost effective supervision and training of contractors the Development Directorate has piloted the organization of Zibambele contractors into savings clubs. A constitution, developed in consultation with Zibambele contractors, has been prepared. This allows the Development directorate to roll out the establishment of Zibambele Savings Clubs from the original pilot initiatives. The purpose of the Savings Club initiative is to strengthen Zibambele contractors’ roles in rural enterprise development and provide the institutional framework to create wealth amongst the poorest of the poor.

An independent evaluation of Zibambele by SALDRU (University of Cape Town) found Zibambele to be both a cost efficient road maintenance system and a cost effective poverty alleviation programme. The SALDRU finding, in 2001/2002, that seventy three cents of every rand spent within the programme accrued to Zibambele contractors compares very favourably with other poverty alleviation programmes both in South Africa and internationally. Zibambele was piloted by the Development Directorate in 1999/2000, (2 700 contracts issued). Zibambele has already achieved more than one third of the targeted contracts.

eThekwini Municipality

The eThekwini municipality manages 4000 beneficiaries in a separate programme to the Zibambele programme of the KZN Department of Transport.

These beneficiaries (known as Zibambele contractors) are contracted to maintain a section of blacktop or gravel road. Their main focus is on low intensity routine maintenance such as clearing of road surfaces, drains and verges.

The beneficiaries are issued with tools such as rakes, spades, hoes and slashers and safety equipment such as reflective vests, gloves and traffic cones to carry out their allocated tasks.

They are contracted to work on their section of road for eight days for which they receive a stipend based on the Expanded Public Works Programme (EPWP) guidelines and the province's minimum labour rates.

Botswana (Department of Roads)

The Botswana Road Maintenance Contract System is a poverty alleviation programme creating sustainable jobs for poor rural families while they maintain national and rural roads. In order to break poverty cycles in the medium to long term the Department employs a household rather than an individual. This ensures that a household does not rely on one person for continuity of the contract.

Activities that are included are:

- Maintenance of drainage structures (culverts, drifts and Causeways)
  - Inlet and outlet maintenance (erosion control)
  - maintenance of side drains

- Road Reserve Maintenance
  - Vegetation Control
  - Control of Animals
  - Rest Area Maintenance
  - Litter Control

- Bicycle Patrol of Roadway Section
  - Identification and reporting of defects
  - Cattle chasing
  - Accident Reporting

References

- Local roads for rural development in KwaZulu – Natal (CARNS Report) March 1997: Kwazulu-Natal Department of Transport

- Kwazulu-Natal website: www.kzntransport.gov.za (search Zibambele)

- Information technology assisting the destitute in eThekwini municipality – Civil Engineering: November/December 2006 (Vol. 14 No. 11)

Appendix 29: MINOR BASE REPAIR UTILISING ETB

1. General comments and establishment of integrity of foundation

Minor failures can be identified from the appearance of the surfacing and the shape of the surface, e.g.

If the surface is cracked (crocodile cracked) and the surface is undulating, shoving or moving over relatively short lengths, i.e. 2 – 3 m, then the failure of the material extends only into the base. If the area outside the cracked area is sound (no cracking), it is probably due to the distress in the surfacing and ingress of water has caused the base to fail. (See Photo B6 – Routine Road Maintenance Guidance Manual – June 2000 (SANRAL))

It is possible to have a crocodile cracked surface where the levels of the road surface are still sound, i.e. the base and foundation of the road is sound and no repairs are required for the base or subbase layers. The quickest way of establishing the integrity of an existing road foundation is to do a few DCP tests in the distressed area or open up $\pm$ ½ m^2 and inspect the surface of the base and see if the cracks or "failures" have penetrated the base. (See Photo's C20 and B10 – Routine Road Maintenance Guidance Manual – June 2000 (SANRAL))

The main provincial roads and national roads in South Africa have generally been soundly designed and constructed for the last 50 years and failures have been mainly due to lack of maintenance and ingress of water into the system, in conjunction with overloading of trucks.

If test facilities for DCP testing are not available, the following procedure is recommended:

i. Remove the distressed surfacing and inspect the base – is the base loose, cracked and in some cases filled/wet with water?
ii. If stabilised, is it cracked – are the cracks primary cracks or secondary cracks?

Remove all unsound material and inspect the surface of the subbase after it has been cleaned by brooming.

i. Inspect the surface of the subbase and establish if the subbase is sound and properly compacted.
ii. If the subbase has been stabilised and even if there are some primary cracks, do not remove the subbase.
iii. If the subbase is loose and wet, establish where the water is coming from by digging a small (150mm) sump and observing any flow of water into the sump.
iv. If the subbase is wet and clayey, and it has been established that water has not originated from the side or the bottom layers but from the base and surfacing, remove the subbase and stabilise it with lime or replace the layer with stabilised ETB. This is seldom the case on fairly modern road construction.
v. If there is a free flow water from the sides or bottom of the sump in the subbase, herringbone or subsurface drains might be required.

2. Tools and equipment

- Drum stand and ball valve (drum can be placed on truck/LDV – must have ball valve for easy decanting)
- Concrete mixer (for small areas hand mixing is acceptable)
- Watering can
- Measuring tape
- Chalk line
- Broom
- Picks
- 2 wheelbarrows
- 4 shovels

- 2 steel squeegees
- 4 hand tampers
- 1 screeding board
- 4 x 25 litre measuring containers
- 2 x 20 litre measuring containers
- 2 x 5 litre measuring containers
- 1 pedestrian roller (65/76 BOMAG), plus trailer, if available
- 25 x 25 mm box sections (gauges)
- 50 x 50 mm box sections (gauges)
- Plastic sheeting/cover

3. Materials

- Aggregate/gravel (in situ) or suitable imported material
  (Generally the existing base is of fairly sound material and can be used for constructing a new ETB layer. If the base was stabilised with lime/cement, this material can be broken down to acceptable grading for the ETB. If the material is well graded but has a PI >6, add 1% of lime to material.)
- Cement : 2 pockets in a sealed container
- 60% stable grade anionic emulsion : 1 drum
- Water

4. Preparation of excavation and treatment of base failure

- The extent of the failure should be marked out with chalk lines in geometrical areas 150 to 200 mm wider than the failure (**Figure 1a**).

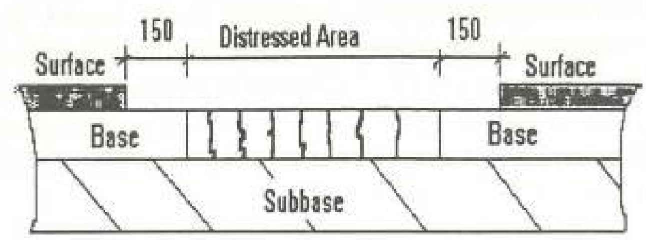

Figure 1(a)

In the case of slacks in the road surface resulting from inter alia inadequate back filling of drainage structures and other trenches, the slack should be string lined to determine the extent of the slack (**Figure 1b**).

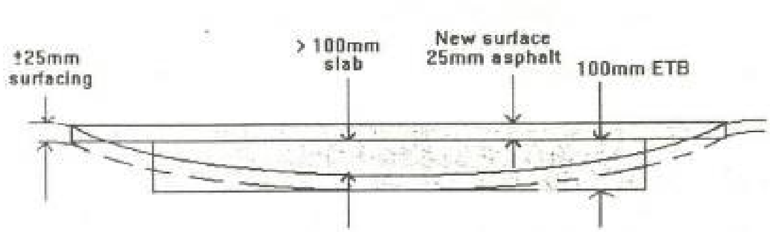

Figure 1(b)

* First, neatly remove the surface as marked out with the chalk lines and then the base which has failed (See **Figures 1 and 2)**

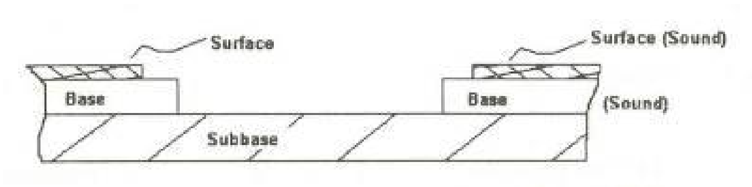

Figure 2   Base failure showing distressed area removed

* Inspect the subbase for any signs of possible failure or ingress of water. If the subbase is sound, compact the loose material and trim the subbase and the vertical sides of the excavation (See **Figure 2**)
* Apply a diluted (1:6) stable grade emulsion to the subbase and to the vertical sides of the excavation with a watering can. Spread the emulsion evenly with wet brooms and brushes. (**Photo 1)**

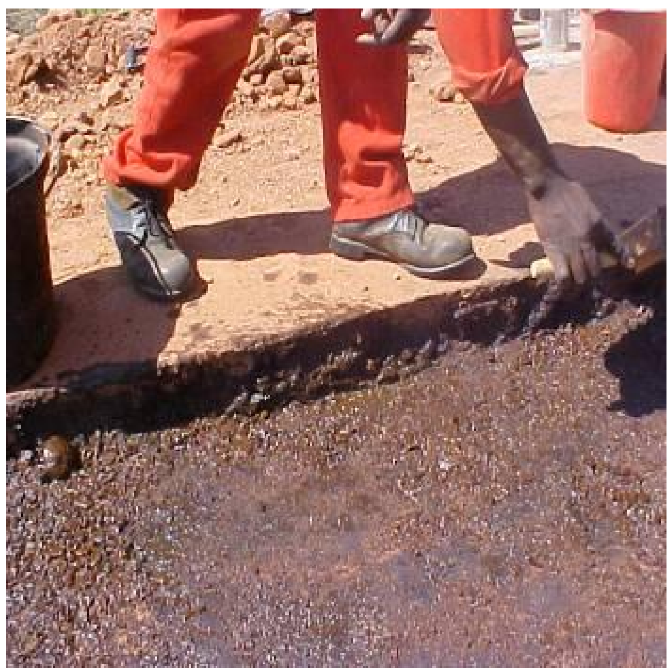

Photo 1

5. Mix proportions for ETB base repairs

5.1. Using wheelbarrows

- If the method of measuring the proportions is done by using wheelbarrows:

Aggregate	1 wheelbarrow (69 litres)
Cement	1 kg ($^2/_3$ litre)
Emulsion (60% stable grade anionic)	2 litres
Water (Approx)	5½ litres
Lime (PI > 6)	$^2/_3$ kg ($^2/_3$ litre)

- Method of mixing:

a) Mix aggregate and cement dry in one wheelbarrow = 69 litres
b) Mix 3½ litres of water with aggregate and cement
c) Dilute the emulsion (2 litres) with 2 litres of water
d) Add diluted emulsion to the aggregate + cement + water mixture and mix to uniform consistency

5.2. Using small concrete mixer and 25 litre cans

- If a small concrete mixer (180/200) and 25 litre measuring cans are to be used the proportions are as follows:

Aggregate	5x25 litre cans (125l)	6x25 litre cans (150l)
Cement	1 $^2/_3$ kg (1 litre)	2 kg (1$^1/_3$ litres)
Emulsion (60% stable grade anionic)	5 litres	6 litres
Water (Approx)	10 litres	12 litres
Lime (PI > 6)	1 kg (1 litre)	1$^1/_3$ kg (1$^1/_3$ litres)

- Mixing procedure:

  - Add aggregate and cement to mixer and mix well
  - Add $^2/_3$ water to mix in mixer and mix well
  - Add $^1/_3$ water to emulsion and add diluted emulsion to contents of mixer and mix till uniform consistency

Note:

- **For the last lift of 75 mm (loose), add an extra 1½ litres of emulsion to the mix.**
- **Always mix aggregate and cement dry and then add the water before adding the diluted emulsion.**
- **The emulsion to be used is an anionic stable grade emulsion produced preferably with vinzyl resin.**

5.3. Construction process

- Place the emulsion treated base (ETB) in layers of not more than 75 mm loose, in the excavated base, and compact this material with tampers for small areas (less than 2 – 4 m^2) or with a pedestrian roller for larger areas (greater than 4 m^2). **(Photo 2**)

Photo 2

*Note the placing of the ETB within the area to be repaired must be done at a uniform spacing to achieve the minimum amount of movement of the loose material to achieve the desired uncompacted thickness. Steel squeezes and a steel screed bar should be used to spread the loose material to the desired uncompacted thickness. Less segregation is attained using steel squeeges than in the case when rakes are used.

- For the final layer of ETB, i.e. the last 75 mm loose or 50 mm compacted, it is recommended that the latter be enriched with an extra 1,5 litres of emulsion per batch of 150 litres of gravel. To obtain a smooth finish level with the existing sound base a screeding board must be used in conjunction with 25 x 25 mm steel box sections. (**Figure 3. and Photo 3)**

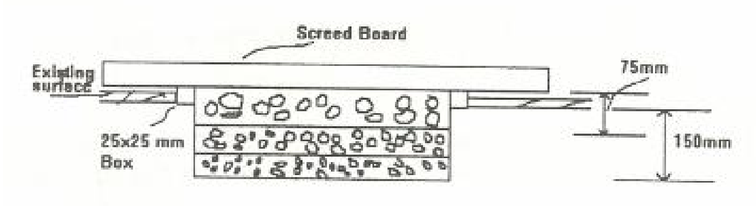

Figure 3: Obtaining finish level for base repair

Photo 3

- Compact the last 75 mm loose layer until it is level with the existing base.

  Once the emulsion has broken, and depending on the thickness of the existing surface, this repair can be left open to traffic without damage for at least 4 – 6 weeks. If it is required to be open to traffic for longer periods, diluted emulsion (stable grade anionic) can be applied to the surface and broomed/slushed into the surface. (Dilution of the emulsion should be 1 part of emulsion to 6 parts of water).

  If the surface is enriched with diluted emulsion, it is recommended the existing surface be protected by masking it with reinforced paper or malthoid to give a neat appearance of the completed work.

5.4. Method of rolling

Wrong rolling can result in building undulations into the surface. Using a BOMAG 76 roller the following procedure is recommended (**Figure 4**):

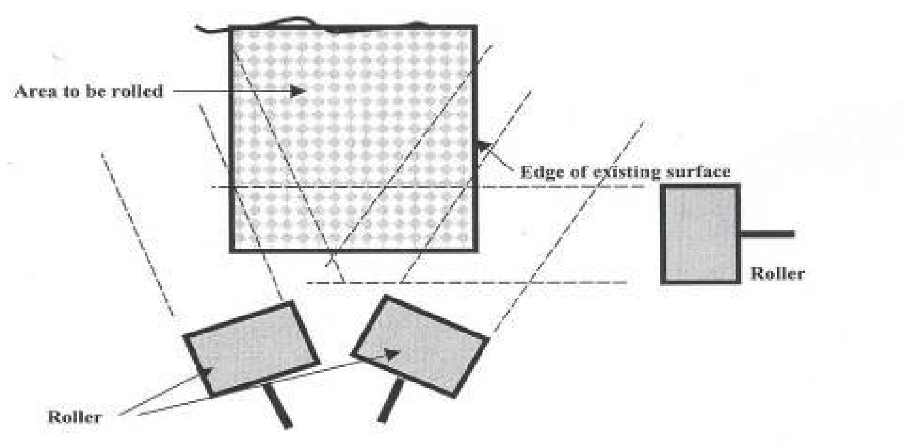

Figure 4

- Once the ETB has been laid loose to its finished level approach the ETB at approximately 45^{o} angle so that the roller is supported by the edge of existing surface (**Photo 4)**.

Photo 4

- Roll each triangle alternatively, moving approximately $^{1}/_{3}$ of a drum width at a time so that the bulk of the roller is either being supported by the edge of existing road or the compacted material (**Photo 5**).

Photo 5

- After 1or 2 pass parallel to the centre line of the road on either side of the section, there will be an overspill of ETB. Scoop off and clean the overspill before continuing to roll, moving $^{1}/_{3}$ of a roller width alternatively towards the centre of the section (**Photo 6**).

Photo 6

- When commencing the rolling, start in the vibrating mode and not the non-vibrating mode.
- Continue rolling until the ETB is level with the edge of the existing road.
- Check the surface with a straight edge for undulations, levels, corrugations and rectify as soon as possible on the same day of construction.

5.5. Selection of surfacing

- The selection of the surfacing to be used on the above work will depend on the thickness of the existing surface.

Note: If the road is up for rehabilitation within the next two years, this will affect the level to which the ETB could be constructed. The ETB can then be completed to the level of the existing surface using a 9,7 mm pre-manufactured patch. This will substantially expedite the work.

- If the existing surface consists of a double seal or triple seal and is not thicker than 10 mm, the replacement surface can either be a coarse slurry seal or a 13 mm pre-manufactured patch.

- If the thickness of the existing surface is greater than 10 mm and less than 20 mm, a Cape seal can be selected, i.e. 19 mm aggregate plus a slurry seal.
- If the thickness of the existing surface is greater than 20 mm, hot mix asphalt can be selected or a modified Cape Seal can be applied using larger aggregates than 19 mm.

Note: Cold asphalts are not recommended for repairs as they are either open graded and allow water to penetrate, or they ravel or they are unstable.

There are, however, specially developed cold mixes which are pre-packed. These should be thoroughly investigated for voids and stability before use.

Appendix 30: EDGE BREAK REPAIR

1. Tools and equipment

- Small pedestrian roller
- Specially made shuttering with “pins”/pegs for securing the shuttering in place –1,5m lengths. See 3.2(ii)
- Steel squeeges
- Gauges for spreading material 1.5 x thickness of layer applied – see par. 4.

2. Materials

- Asphalt/premix (preferably hot)
- 60% anionic stable grade emulsion
- Water
- Medium grade/coarse grade aggregate as required
- Cement as required for slurry (in can with lid)

3. Preparation and construction

3.1. Preparation

- Select the best line parallel to the centre line of the road which will accommodate the edge break and place a chalk line for neatly cutting the surfacing and part of the base as indicated in sketch (**Figure 1**), to a minimum depth of 50 mm below existing surface.

- Remove all loose material and treat the edge of the cut line and the exposed base with 1:8 diluted emulsion using a wet bass broom to distribute the emulsion.
    - o (A half 210 litre drum or wheelbarrow of water, should be readily available, for washing the bass broom every so often to avoid the bitumen clogging the broom).
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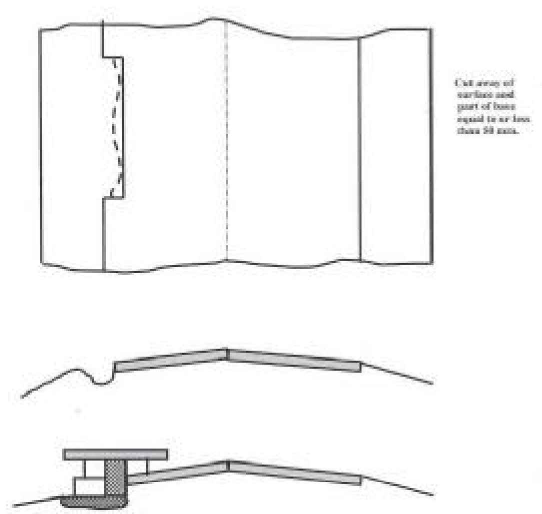

Figure 1

3.2. Break deeper than 50 mm

- If the break is > 50 mm, replace with emulsion treated selected material and compact a neat smooth surface 50 mm below existing surface to receive the premix (**Figure 2)**.
- Use a 50 mm x 50 mm heavy box section as a shutter to contain the premix.

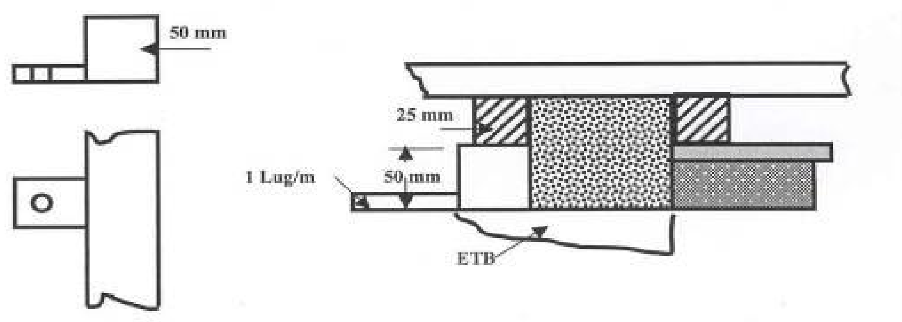

Figure 2

- Use two 25 mm x 25 mm screed gauges for placing 75 mm of premix loose. Before placing the premix, tack the surface and the edge of the cut surface with diluted emulsion.

  Note: First remove the 25mm x 25mm gauges before compaction starts.

- Compact the premix with a vibratory roller until the new premix is level with the existing road surface.
- Replace shoulder material and compact at optimum moisture content to obtain a neat finish.

3.3. Surface edge break

If only the surface constitutes the edge break and the base is sound, chip out a depth of 25 mm below the existing surface and use the 50 mm box sections for shuttering without the gauges but use a 13 mm timber slat or steel plate on the existing surface for screeding the loose premix(**Figure 3)**.

Before rolling commences, remove the slat and compact to level of existing surface. The roller must only cover the area from the inside edge of 50 mm box. Retain the box during rolling – it protects the premix from moving.

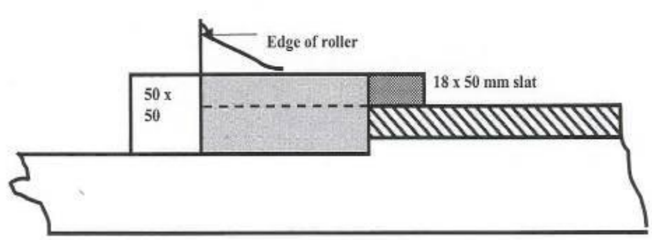

Figure 3

As the edge breaks are generally fairly narrow widths less than 500 mm, the steel squeezes can be used instead of the screed bar.

Appendix 31: THE SOUTH AFRICAN EXPANDED PUBLIC WORKS PROGRAMME

1. The South African Expanded Public Works Programme[20]

1.1 Background

"Expanded" from what?

In 1994 the new democratic government launched its National Public Works Programme. This programme failed to achieve its major objective of re-orienting public expenditure so as to generate employment and skills.[21] Unfortunately, the responsibility for infrastructure was located in a department that was not responsible for infrastructure but public buildings. Once this had been realized the department concentrated its efforts upon community based relief and small contractor development. The major construction industry was not involved. The effect of the National Public Works Programme was not perceptible in the major economy.

1.2 Legislation

In the long run, one of the positive elements to emerge from the National Public Works Programme was that the labour legislation necessary for a successful Public Works Programme finally became law in January 2002. The source of the concepts and wording for this legislation was the 1993 Framework Agreement, which had been negotiated between the construction industry and the Congress of South African Trade Unions (COSATU). [22]

After much negotiation and discussion between 1994 and 2002, the Basic Conditions of Employment Act 1997, was amended.

On the 25th January 2002 the Government Gazette (No. 23045) of South Africa published the following:

- No R63 Basic Conditions of Employment Act, 1997
- Ministerial Determination: Special Public Works Programmes.
- No R64 Basic Conditions of Employment Act, 1997
- Code Of Good Practice For Employment And Conditions Of Work For Special Public Works Programmes.

Full details may be found in the Gazette. Here we wish to highlight a few of the principal features.

In the Ministerial Determination (R63), *inter alia*, it was stated:

"Special public works programme" means a programme to provide public assets through a short-term, non-permanent, labour-intensive programme initiated by government and funded from public resources…

- "task" means a fixed quantity of work;
- "task-based work" means work in which a worker is paid a fixed rate for performing a task;
- Workers on a SPWP are employed on temporary basis.
- A worker may NOT be employed for longer than 24 months in any five-year cycle on a SPWP.

[20] Greater detail in McCutcheon et al (2005) in McCutcheon and Fitchett (2005a)
[21] NCLIC-COSATU-SANCO (1993)
[22] NCLIC-COSATU-SANCO (1993)

- Employment on a SPWP does not qualify as employment as a contributor for the purposes of the Unemployment Insurance Act 30 of 1966.

  The Schedule "Code of Good Practice" (R64) included, *inter alia*:

- A SPWP is a short-term, non-permanent, labour-intensive programme initiated by government and funded either fully or **partially**[23], from public resources to create a public asset.
- On the task-based system, a worker is only paid for each task completed
- A "no work – no pay" rule must apply <u>except</u> in the following circumstances: Injury and illness
- Training is regarded as a critical component of SPWP. Every SPWP must have a clear training programme that strives to ensure a minimum of 2 days training for every 22 days worked.

Most of the issues, which were central to the original 1993 Framework Agreement, as far as conditions of employment were concerned, are now embodied in Legislation. It is important that the elements quoted above are seen in the context provided in the amendments. This can only be fully achieved by reference to the complete documents. In essence, labour legislation in South Africa now incorporates the major provisions required for the implementation of labour-intensive work; and thus the requisite labour legislation on which to build the Expanded Public Works Programme, to which we now turn.

1.3 An outline of the objectives of the Expanded Public Works Programme

In February 2002 one of the resolutions of ANC's Growth and Development Summit was a commitment to:

- An expansion in public investment initiatives…to create jobs. [24]

  In December 2002 the 51st ANC conference resolved:

- An expanded public works programme must be a major priority … providing infrastructure, in particular basic social and municipal services through labour-intensive methods to maximise job creation and skills development.

  And in his State of the Nation speech in February 2003, the President stated that:

- … the government has decided that we should launch an expanded public works programme. This will ensure that we draw significant numbers of the unemployed into productive work, and that these workers gain skills while they work, and thus take an important step to get out of the pool of those who are marginalised…

As a result government decided to initiate an Expanded Public Works Programme. "Expanded", because it was considered to be an expansion of the National Public Works Programme. Responsibility was located in the Department of Public Works, which by now had much more experience with infrastructure than in 1994.

So much for the formal institutionalisation of the Expanded Public Works Programme (hereafter referred to as the Programme); we will now turn to its objectives, then to its "Conditionalities" related to expenditure through formal channels, audits, types of infrastructure for which the use of labour-intensive methods is mandatory, contract clauses and documentation, and compulsory training . In closing we will demonstrate one of many reasons why training has to be mandatory if the work is to be implemented properly.

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[23] Emphasis added
[24] NCLIC-COSATU-SANCO (1993)

Goal

To alleviate unemployment for a minimum of one million people in South Africa, of which at least 40% will be women, 30% youth and 2% disabled, between 2004 and 2009.

Purpose

To achieve this goal the Government will:

- Over the **first** five years of the programme create temporary work opportunities and income for at least one million unemployed people.
- Provide needed public goods and services, labour-intensively, at acceptable standards, through mainly public sector resources and public and private sector implementation capacity.
- Increase the potential of participants to earn a future income by providing work experience, training and information related to local work opportunities, further education and training and S(mall)M(edium and)M(icro)E(nterprise) development.

This would be achieved by creating work opportunities in the following four ways (i.e. Sectors):

- Increasing the labour intensity of government-funded infrastructure projects
- Creating work opportunities in public environmental programmes
- Creating work opportunities in public social programmes
- Utilising general government expenditure on goods and services to provide the work experience component of small enterprise learnership / incubation programmes.

and

- The programme will target the unemployed and marginalised.

It must be stressed that the Expanded Public Works Programme therefore covers four sectors: Infrastructure; Environment; Social; and Economic.

We will focus upon Infrastructure. However, experience during the past two years suggests that the lessons learnt in relation to the infrastructure sector are common to the other three and that similar training methodologies could be applied in these.

The three principal objectives of the Infrastructure component are:

- Productive employment generation;
- Individual skills development;
- Technically-sound, cost-effective infrastructure.

Government intends to ensure that its objectives will be achieved. National Treasury has set "Conditionalities" regarding access to funds and subsequent expenditure in relation to the following:

- Institution;
- Type of infrastructure;
- Requisite Contract Documentation: Guidelines for Implementation;
- Compulsory training.

1.4 "Conditionalities" of the Expanded Public Works Programme

1.4.1 "Conditionalities" 1: Institution, Infrastructure Type and DORA Compliance

1.4.1.1 Institution

As regards expenditure on physical infrastructure, the most important point is that it will take place through the formal channels for the provision of physical infrastructure; that is, the Municipal Infrastructure Grant and the Provincial Infrastructure Grant. It is important to stress that the funding allocated for the Expanded Public Works Programme is part of normal government expenditure and must follow normal procedures as specified by National Treasury under the Division of Revenue Act. These procedures include an annual audit. Thus, the funding is not an “add-on” for emergency/poverty/drought relief. This marks a significant difference between the Expanded Public Works Programme and all previous programmes of this nature in South Africa. Thus, labour-intensive construction has been brought into the normal budget and is therefore part of the major economy, albeit, as yet, a small part.

It is important to note here that there are two distinct institutions that control the Programme - the Department of Public Works, through its Expanded Public Works Unit, that assists Provinces and Municipalities in identifying and delivering infrastructure, while the Treasury takes on the role of monitoring the work in terms of compliance with the legislated “conditionalities”. This allows for public accountability, in contrast with previous labour-intensive programmes.

1.4.1.2 Type of Infrastructure

At the time of the initiation of the Programme, the Department of Public Works had estimated that over the following five years about R100 billion[25] would be spent through municipal and provincial processes on all types of public infrastructure.

Of the R100 billion, it was estimated that R15 billion[26] would be spent on the following types of construction:

- Low-cost, low-volume urban and rural roads;
- Stormwater drainage;
- Pedestrian sidewalks and cycle paths;
- Trenches.

To repeat, these specific types of construction are the initial focus of the Infrastructure component of the Expanded Public Works Programme. A major reason being that in relation to these types of construction works, there is extensive experience and documented evidence to show that the proper use of labour-intensive methods can be competitive with conventional capital-intensive methods in terms of cost, time and quality, provided that attention is paid to the various important factors mentioned above and in the Appendices.

Labour-intensive construction for higher standard, higher cost construction has not been discouraged. On the contrary it is hoped that some authorities will engage on higher standard work. While there is potential for far greater use of labour-intensive methods in the construction of high standard, heavily trafficked roads, and we have seen that government intends to allocate funding to large-scale projects, current experience on such construction is limited to a small portion of the construction industry.[27] Thus, the architects of the Programme decided to initially focus on specific categories of construction which are amenable to the use of highly labour-intensive methods.

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[25] Since the start of the Programme far greater expenditures on infrastructure have been proposed. However the bulk of the new estimates have been in relation to parastatal expenditures including electrical supply and telecommunication.
[26] NCLIC-COSATU-SANCO (1993)
[27] See below Section 7.7.1)

1.4.1.3 Division of Revenue Act (DORA) Compliance

Expanded Public Works Programme conditions have been placed on the Provincial and Municipal Infrastructure Grants via the 2004 Division of Revenue Act, which requires provinces and municipalities to execute all low-volume roads, stormwater drains, and trenching work in a labour-intensive way, in accordance with guidelines produced by Department of Public Works, and approved by the South African Local Government Association and National Treasury.

A major "conditionality" is that the client (the municipal or provincial authority responsible for the expenditure of the municipal/provincial infrastructure grant) will be audited by Treasury to assess whether the funds allocated have indeed been spent using labour-intensive methods. If not generating significant additional employment opportunities per unit of expenditure, the funding will not be provided for the following year.

The Department of Public Works[28] is engaging in an ongoing communication programme with municipalities and the construction industry regarding the application of these conditions, and is working with the Auditor General to carry out audits to detect non-compliance with the Division of Revenue Act.

1.4.2 "Conditionalities" 2: The Guidelines: Contract and Documentation

Lack of coherence in contractor documentation has been one of the major problems facing those dealing with labour-intensive construction. Partly because of the use of the word "labour", the extent to which labour-intensive construction requires innovation is not appreciated. Having said that, the industry's general rejection of labour-intensive methods, discussed in more detail elsewhere,[29] is a tacit acknowledgement of the degree of innovation required by comparison with conventional methods. Consultants realise that they will have to generate "new" contract documentation including designs, specifications, bills of quantities and contract clauses.[30] They are not able to draw upon shelf designs. Innovation has direct negative in-house time and cost implications. Furthermore, of perhaps even greater importance, consultants are concerned about the effect of the unknown upon their professional indemnity.

The client is directly advised by the consultants and indirectly by opinions expressed by the Contracting fraternity. The mantra "costs more, takes longer, low-quality, more difficult to manage," is a powerful disincentive for the authority responsible for the expenditure of public funding. Government's rhetoric regarding employment generation, skills development and poverty alleviation are all very well. But can these be achieved without detriment to the public funds for which the client is not only responsible, but accountable? What is more likely to be assessed at the end of each financial year: poverty alleviation or expenditure? Which is easier to assess? Reflection on the answers to these questions reveals that it is difficult for the client to entertain the risk implied through any type of innovation let alone one as unconventional as labour-intensive construction.

The contractor has developed systems from tender preparation through implementation, which depend upon particular sets of skills related to conventional methods. Again, the Contractor recognises that innovation requires change, and change entails risk.

Community perceptions and demands further complicate the set of limiting factors related to client, consultant and contractor. Councillors demand that all services should be of a first world standard, without understanding the cost implications. In Soweto, for example, they insist on asphalt paving. And, without proper briefing they assume that labour-intensive methods will result in a lower quality of product. Engineers then use ill-informed community

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[28] The National Department of Public Works is now formally referred to as the Department of Public Works
[29] McCutcheon and Croswell (2003b: 337-385)
[30] "New" to their current office practice, that is. Not "new" in the sense of being completely different to the documentation required for conventional contracts. See comment in footnote

opinions of official community representatives as rationalizations for advising the client not to use alternative technologies.

Re-engineering of Product and Process is essential.[31]

In order to lessen the pain of innovation Guidelines have been produced. In essence the document is an updated version of a component, written by Croswell, of the original Framework Agreement It contains certain items of critical importance; namely:

- Standard wording regarding specifications and standard clauses which must be inserted into whichever form of contract is in general use by a particular client.

- The identification by the consultant of those items in the project that must be done using labour-intensive methods. These items are labelled labour-intensive. The contract states that such items must be done using labour-intensive methods. If not, the contractor will not be paid. The contract wording is such that if the contractor chooses to do the items specified using machines he/she may do so, but then cannot demand payment and cannot challenge the rejection of such a demand: a master class in simplicity.

The Guidelines should ensure much greater uniformity of documentation than was achieved during the National Public Works Programme. A Compact Disc is included in the Guidelines. This means that the consultant may easily introduce the requisite wording and clauses by "dragging and dropping".

It must be stressed that we are not developing a new system of documentation for Labour-Intensive Construction. Elsewhere we have argued that this would lead to the marginalization of labour-intensive construction and lessen the chances of its adoption/absorption by the established construction industry. From the perspective of having a perceptible impact upon skills development, employment generation and long-term poverty alleviation, it is essential that labour-intensive methods become a part of the major economy and are not relegated to the periphery.

The Guidelines provide implementing bodies with the contractual tools that they need to ensure that contractors carry out certain work activities by hand, and to ensure adherence to the minimum requirements for conditions of employment as stipulated in the Code of Good Practice for Special Public Works Programmes.

1.4.3 "Conditionalities" 3: Training

There are two broad categories of training: labour and management.

1.4.3.1 Labour

The Code of Good Practice for Special Public Works Programmes states that
All workers must receive 2 days training for every 22 days worked.

Given that many infrastructure contracts only last 4 to 6 months, the training conditionality only amounts to 8 to 12 days. Therefore little if any technical training can be provided. Thus, training for the labourer will mainly comprise life-skills. This is important from an objective of the Programme to provide a "first step on the ladder" and strengthen a person's ability to access future job opportunities. The training will be provided by the Department of Labour.

[31] In the major economy it is accepted that companies often have to re-engineer to survive or take advantage of new market opportunities. The cost and time involved in Department of Public Works (no date (2004)).

1.4.3.2 Management

The second type of training is that required at all other levels: “hands-on” site supervisors, managers, contractors, consultants and clients (refer to Chapter 5 for details).

“Conditionalities” have been attached to the accredited training that must be proven before funds are disbursed on the labour-intensive construction of the four types of infrastructure as categorized above.

In order to ensure the Programme’s Guidelines are well understood and used properly, the Department of Public Works has undertaken to provide customised training to provincial and municipal officials on the use of the Guidelines.

The Guidelines stipulate that, for these projects to be carried out labour-intensively, provinces and municipalities may only appoint contractors and consulting engineers who undergo training in the design, supervision and management of labour-intensive works. The intention is for these special conditions to create demand for this training, which in turn will stimulate the training providers to train their trainers and get themselves accredited to supply the training. The Construction (Sector) Education and Training Authority has put in place the required National Qualifications Framework (NQF) unit standards and skills programmes, and has paid for training providers to enable them to meet this demand.

A consulting company that wishes to consult on municipal or provincial labour-intensive projects must prove that for a labour-intensive project, specific people in their firm have an NQF Level 5 or NQF Level 7 Skills Programme qualification in Labour-Intensive Construction. Essentially the NQF Level 5 is required for the consultant on site; NQF Level 7 for the consultant responsible for the project at head office level, who is responsible for providing strategic advice to an employer. It must be emphasized that the accreditation is for the individual responsible for the project, not for the company in general.

A Contractor who wishes to tender for labour-intensive work must have the appropriate NQF Level 2 qualification. Furthermore each NQF Level 2 Contractor must employ two people with the qualification “NQF Level 4 Construction Processes Site Supervisor”. These are full NQF qualifications not short-term skills programmes. For example: the NQF Level 4 Construction Processes Site Supervisor qualification requires a combination of a year of classroom and site training (alternating on a weekly basis), followed by at least six months of an internship with an NQF Level 2 Contractor. This qualification has been integrated into the formal “learnership” model established by the Construction Education and Training Authority. It is worth pointing out that this is a generic qualification. By opting to complete other electives such as “water” or “concrete” the person would be able to access other employment opportunities in the construction industry. Above and elsewhere we have termed this person as the “hands on” site supervisor. This emphasises the extent to which the site supervisor is active on site, all day, and every day.

Formal accreditation of these full qualifications and skills programmes has been achieved, partly through the establishment of a “Domain” for “Labour-Intensive Construction” within the Standards Generating Body of the Civil Engineering Industry.

All the training material is in the public domain.

These courses are now being formatted to comply with Continuing Professional Development. This might lessen the need for the current mandatory requirements.

The Construction Education Training Authority has formally accredited at least four different companies in relation to the provision of training in labour-intensive construction.[25]

1.5 In Conclusion

Above we have summarized the objectives of the Expanded Public Works Programme and the conditionalities which National Treasury has set for expenditure. These conditionalities included an overview of the essential aspects required to be incorporated into contracts. Thus the context has been provided within which contracts have to be implemented in accordance with government policy. Full detail of the nature of the contractual documentation will now be provided.

1.6 Guidelines for the Implementation of Labour-Intensive Infrastructure Projects under the Expanded Public Works Programme

1.6.1 Additions

Because of the length of the following text it is thought best to raise two issues, which were not mentioned in the Guidelines, and must be included in future revisions. The need to address these two additional issues has become apparent during implementation of the Programme during the past two years.

- The provision of the requisite data for evaluation must be a contractual obligation and therefore an item in the Bill of Quantities.
- The person responsible for modifying the standard document in line with the stipulations of the "Guidelines" must carefully examine the resulting document to ensure consistency.

Below we will first provide the details as regards the responsibilities of the Public Authority and then the requirements for the contract documentation.

1.7 Guidelines Part 1: Responsibilities of the public body

Responsibilities of the public body.

This consists of:

- Selection of Projects;
- Setting of rate of pay; and
- Appointment of consulting engineers and contractors.

1.7.1 Selection of projects

The public body must implement the following types of civil infrastructure projects labour-intensively, in accordance with these guidelines:

- low-volume roads (typically less than 500 vehicles per day) and sidewalks;
- stormwater drainage; and
- trenching;

Where such projects contain a significant amount of the construction activities for which the use of labour is specified in the Generic Labour-Intensive Specification in section 1.8.3.3 below, i.e. excavation, loading, short-distance hauling, offloading, spreading, grassing, and stone-pitching.

There is also potential for additional employment creation in other types of infrastructure and building (see Chapter 2). Public bodies are also encouraged to create additional work opportunities in these projects. These guidelines may be used for other labour-intensive projects other than those types of civil infrastructure projects specified above, as long as such projects involve a significant substitution of labour for machines.

The public body must be satisfied that sufficient local labour (willing to work) is available for the project, before proceeding with the project as a labour-intensive project.

These guidelines do not have to be applied to projects for which planning had already commenced before the beginning of the 2004-2005 financial year, to avoid reworking existing designs or tender documentation.

1.7.2 Setting of rate of pay

This has been provided in Section 5.3.1

1.7.3 Appointment of consulting engineers and contractors

The public body must ensure that:

- the design of the labour-intensive works by consultants is overseen by persons in their employ who have completed the necessary skills training (see Chapter 5);
- works contracts are administered by persons in the employ of consultants who have completed the necessary skills training (see Chapter 5); and
- works contracts are awarded to contractors who have in their employ managers who have completed the necessary skills training (see Chapter 5).

As a concession up to 30 June 2005, persons identified in Chapter 5 who have not completed the requisite skills training need only to be registered on the relevant skills programmes.

1.8 Guidelines Part 2: Contract documentation for consulting engineers and contractors for labour-intensive construction projects

1.8.1 General

All standard forms of contract applicable in South Africa (see Appendix 27) may be used for labour-intensive projects. It is not necessary to create special new forms of contract or to amend existing forms to implement labour-intensive works.

Requirements for labour-intensive works need, however, to be established in the scope of work / specifications / schedules / works information / scope of services / scope associated with a contract for both consultants and contractors.

Each standard form of contract uses different terms to describe the parties to the contract and to establish requirements for the works (see Appendix 27). These guidelines use the terms employer and contractor for the parties engaged in construction works, client and consultant for the parties engaged in professional service contracts and scope of work for requirements in both professional service and construction contracts. The terms used in the text in boxes may have to be adjusted to reflect the terms used in the particular standard form of contract.

1.8.2 Contract Documentation for Consulting Engineering Services

The scope of work must establish the manner in which the consultant is to provide the consulting engineering services associated with labour-intensive works.

The following must be included in the scope of work in the contract of employment with a Consulting Engineer:

General

The services shall be provided in accordance with the provisions of the Guideline Scope of Service and Tariff of Fees for Persons Registered in terms of the Engineering Professions Act published by the Engineering Council of South Africa in terms of Board Notice No 18 of 2003 in Government Gazette No 24938, 28 February 2003).

Labour-intensive works

- The Consultant shall not perform any significant portion of a project involving labour-intensive works under the direction of a staff member who has not completed, or, for the period 1 April 2004 to 30 July 2005, is not registered for training towards, the NQF level 7 unit standard “Develop and Promote Labour-Intensive Construction Strategies”
- The staff member of the consultant who is responsible for the administration of any works contract involving labour-intensive works must have completed or, for the period 1 April 2004 to 30 July 2005, be registered for training towards, the NQF level 5 unit standard “Manage Labour-Intensive Construction Projects” The Consultant must provide the Client with satisfactory evidence that staff members satisfy the requirements of 1 and 2.
- The Consultant must design and implement the construction works in accordance with the Guidelines for the Implementation of the Labour-Intensive Projects under the Expanded Public Works Programme (the Guidelines) published by the national Department of Public Works.
- The Consultant shall for monitoring purposes, transmit to the Client data obtained from the contractor on the number of people employed, broken down into the amounts spent on women, youth, and persons with disability on the project, the number of person days of employment created and the number of days of formal training provided.
- All services relating to the implementation of the works which are to be provided in terms of the Guidelines are normal services in terms of ECSA’s Board Notice No 18 of 2003. Any changes in the design of the works to incorporate labour-intensive works shall not constitute a change in scope or an additional service.
- The Consultant shall certify that the works have been completed in accordance with the requirements of the Guidelines and the Contract:
    - whenever a payment certificate is presented to the Client for payment; and
    - immediately after the issuing of a practical completion certificate that signifies that the whole of the works have reached a state of readiness for occupation or use for the purposes intended although some minor work may be outstanding.

1.8.3 Contract Documentation for the Works

1.8.3.1 Conditions of tender

Public bodies must only award contracts to contractors who have suitably qualified senior and middle supervisory staff to supervise the labour-intensive works. Tenderers must be made aware of this requirement in tender documents. Those responsible for evaluating tenders must confirm that the contractor has such staff available for the contract during the tender evaluation process.

The following must be included in the tender data / conditions of tender in the contract with the Employer:

Eligibility requirements

A contract will only be entered into with a tenderer who has in his employ management and supervisory staff satisfying the requirements of the scope of work for labour-intensive competencies for supervisory and management staff.

Information to be submitted with the tender

The tenderer shall, when requested by the Employer to do so, submit the names of all management and supervisory staff that will be employed to supervise the labour-intensive portion of the works together with satisfactory evidence that such staff members satisfy the eligibility requirements.

1.8.3.2 Conditions of contract

Any standard form of contract for construction works may be used for labour-intensive projects (see Appendix 27). These forms of contract must not, however, be amended or varied to alter the obligations, liabilities or rights of the employer, representative of the employer (engineer / principal agent / agent / project manager) or contractor where a project manager, materials manager, trainer, mentor or any other person is appointed to support the Contractor.

The following must be included in the contract data / special conditions of contract in the contract with the Employer:

- Payment for the labour-intensive component of the works.
- Payment for works identified in the Scope of Work as being labour-intensive shall only be made in accordance with the provisions of the Contract if the works are constructed strictly in accordance with the provisions of the scope of work. Any non-payment for such works shall not relieve the Contractor in any way from his obligations either in contract or in delict.

Applicable labour laws

The contractual details regarding the employment of labour have been provided above in Chapter 5 on Labour. They are repeated here because they are part of the contractual requirements.

The Ministerial Determination, Special Public Works Programmes, issued in terms of the Basic Conditions of Employment Act of 1997 by the Minister of Labour in Government Notice N° R63 of 25 January 2002, as reproduced below, shall apply to works described in the scope of work as being labour-intensive and which are undertaken by unskilled or semi-skilled workers.

1.8.3.3 Generic Labour-intensive Specification

(This specification must be incorporated in the Scope of Works without amendment or modification. When SANS 1921-5, Construction and management requirements for works contracts Part 5: Earthworks activities which are to be performed by hand, is published, the earthworks portions of this generic specification must be replaced with a reference to SANS 1921-5 and its associated specification data).

Scope

This specification establishes general requirements for activities which are to be executed by hand involving the following:

- trenches having a depth of less than 1.5 metres
- stormwater drainage
- low-volume roads and sidewalks

Precedence

Where this specification is in conflict with any other standard or specification referred to in the Scope of Works to this Contract, the requirements of this specification shall prevail.

Hand excavateable material

Hand excavateable material is material:

- granular materials:
  - o whose consistency when profiled may in terms of table 7.1 be classified as very loose, loose, medium dense, or dense; or
  - o where the material is a gravel having a maximum particle size of 10mm and contains no cobbles or isolated boulders, no more than 15 blows of a dynamic cone penetrometer is required to penetrate 100mm;

- cohesive materials:
  - o whose consistency when profiled may in terms of table 1.1 be classified as very soft, soft, firm, stiff and stiff / very stiff; or
  - o where the material is a gravel having a maximum particle size of 10mm and contains no cobbles or isolated boulders, no more than 8 blows of a dynamic cone penetrometer is required to penetrate 100mm;

Note:

- A boulder, a cobble and gravel is material with a particle size greater than 200mm, between 60 and 200mm.
- A dynamic cone penetrometer is an instrument used to measure the insitu shear resistance of a soil comprising a drop weight of approximately 10 kg which falls through a height of 400mm and drives a cone having a maximum diameter of 20mm (cone angle of 60° with respect to the horizontal) into the material being used.

Table 1.1: Consistency of materials when profiled

GRANULAR MATERIALS		COHESIVE MATERIALS	
CONSIS-TENCY	**DESCRIPTION**	**CONSIS-TENCY**	**DESCRIPTION**
Very loose	Crumbles very easily when scraped with a geological pick.	Very soft	Geological pick head can easily be pushed in as far as the shaft of the handle.
Loose	Small resistance to penetration by sharp end of a geological pick.	Soft	Easily dented by thumb; sharp end of a geological pick can be pushed in 30-40 mm; can be moulded by fingers with some pressure.
Medium dense	Considerable resistance to penetration by sharp end of a geological pick.	Firm	Indented by thumb with effort; sharp end of geological pick can be pushed in up to 10 mm; very difficult to mould with fingers; can just be penetrated with an ordinary hand spade.
Dense	Very high resistance to penetration by the sharp end of geological pick; requires many blows for excavation.	Stiff	Can be indented by thumb-nail; slight indentation produced by pushing geological pick point into soil; cannot be moulded by fingers.
Very dense	High resistance to repeated blows of a geological pick.	Very stiff	Indented by thumb-nail with difficulty; slight indentation produced by blow of a geological pick point.

Trench excavation

All hand excavateable material in trenches having a depth of less than 1,5 metres shall be excavated by hand.

Compaction of backfilling to trenches (areas not subject to traffic).

Backfilling to trenches shall be placed in layers of thickness (before compaction) not exceeding 100mm. Each layer shall be compacted using hand stampers a) to 90% Proctor density; b) such that in excess of 5 blows of a dynamic come penetrometer (DCP) is required to penetrate 100 mm of the backfill, provided that backfill does not comprise more than 10% gravel of size less than 10mm and contains no isolated boulders, or c) such that the density of the compacted trench backfill is not less than that of the surrounding undisturbed soil when tested comparatively with a DCP.

Excavation

All hand excavateable material including topsoil classified as hand excavateable shall be excavated by hand. Harder material may be loosened by mechanical means prior to excavation by hand. The excavation of any material which presents the possibility of danger or injury to workers shall not be excavated by hand.

Clearing and grubbing

Grass and small bushes shall be cleared by hand.

Shaping

All shaping shall be undertaken by hand.

Loading

All loading shall be done by hand, regardless of the method of haulage.

Haul

Excavation material shall be hauled to its point of placement by means of wheelbarrows where the haul distance is not greater than 150 m.

Offloading

All material, however transported, is to be off-loaded by hand, unless tipper-trucks are utilised for haulage.

Spreading

All material shall be spread by hand.

Compaction

Small areas may be compacted by hand provided that the specified compaction is achieved.

Grassing

All grassing shall be undertaking by sprigging, sodding, or seeding by hand.

Stone pitching and rubble concrete masonry

All stone required for stone pitching and rubble concrete masonry, whether grouted or dry, must to be collected, loaded, off loaded and placed by hand. Sand and stone shall be hauled to its point of placement by means of wheelbarrows where the haul distance is not greater than 150m. Grout shall be mixed and placed by hand.

Manufactured Elements

Elements manufactured or designed by the Contractor, such as manhole rings and cover slabs, precast concrete planks and pipes, masonry units and edge beams shall not individually, have a mass of more than 320kg. In addition, the items shall be large enough so that four workers can conveniently and simultaneously acquire a proper handhold on them.

1.8.3.4 Schedules of quantities

Labour-intensive works must be highlighted in the schedules / bills of quantities for the payment items relating to labour-intensive works.

The following wording, as appropriate, may be included in the preamble or pricing instructions to the schedules / bills of quantities in the contract with the contractor:

- Those parts of the contract to be constructed using labour-intensive methods have been marked in the bill of quantities with the letters LI in a separate column filled in against every item so designated. The works, or parts of the works so designated are to be constructed using labour-intensive methods only. The use of plant to provide such works, other than plant specifically provided for in the scope of work, is a variation to the contract. The items marked with the letters LI are not necessarily an exhaustive list of all the activities which must be done by hand, and this clause does not over-ride any of the requirements in the generic labour-intensive specification in the Scope of Works.

- Payment for items which are designated to be constructed labour-intensively (either in this schedule or in the Scope of Works) will not be made unless they are constructed using labour-intensive methods. Any unauthorised use of plant to carry out work which was to be done labour-intensively will not be condoned and any works so constructed will not be certified for payment.

The following payment items should be included in the bill of quantities:

Item	Description	Unit	Quantity	Rate	Amount
	Training allowance paid to targeted labour iro formal training	Person days	(insert quantity)	(insert specified day rate)	
	Extra over for the administration of payment of training allowances to targeted labour	Person days	(as above)		
	Transport and accommodation of workers for training where it is not possible to undertake the training in close proximity to the site. (Provisional sum)	Sum	(insert provisional sum)		

Item Description Unit Quantity Rate Amount

Training allowance paid to targeted Person (insert (insert specified day labour in terms of formal training days quantity) rate) Extra over for the administration of Person (as above) payment of training allowances to days targeted labour Transport and accommodation of Sum (insert workers for training where it is not provisional possible to undertake the training in sum) close proximity to the site. (Provisional sum).

Appendix 32: APPLICABLE LABOUR LAWS

1. Applicable labour laws

The Ministerial Determination, Special Public Works Programmes, issued in terms of the Basic Conditions of Employment Act of 1997 by the Minister of Labour in Government Notice N° R63 of 25 January 2002, as reproduced below, shall apply to works described in the scope of work as being labour-intensive and which are undertaken by unskilled or semi-skilled workers.

1.1 The standard terms and conditions for workers employed in elementary occupations on a Special Public Works Programme (SPWP)

a) Introduction

This document contains the standard terms and conditions for workers employed in elementary occupations on a Special Public Works Programme (SPWP). These terms and conditions do NOT apply to persons employed in the supervision and management of a SPWP.

In this document:

- “department” means any department of the State, implementing agent or contractor;
- “employer” means any department, implementing agency or contractor that hires workers to work in elementary occupations on a SPWP;
- “worker” means any person working in an elementary occupation on a SPWP;
- elementary occupation” means any occupation involving unskilled or semi-skilled work;
- “management” means any person employed by a department or implementing agency to administer or execute an SPWP;
- “task” means a fixed quantity of work;
- “task-based work” means work in which a worker is paid a fixed rate for performing a task;
- “task-rated worker” means a worker paid on the basis of the number of tasks completed;
- “time-rated worker” means a worker paid on the basis of the length of time worked.

b) Terms of Work

- Workers on a SPWP are employed on a temporary basis.
- A worker may NOT be employed for longer than 24 months in any five-year cycle on a SWP
- Employment on a SPWP does not qualify as employment as a contributor for the purposes of the Unemployment Insurance Act 30 of 1966.

c) Normal Hours of Work

- An employer may not set tasks or hours of work that require a worker to work:
  - more than forty hours in any week
  - on more than five days in any week; and
  - for more than eight hours on any day.
- An employer and worker may agree that a worker will work four days per week. The worker may then work up to ten hours per day.

- A task-rated worker may not work more than a total of 55 hours in any week to complete the tasks allocated (based on a 40-hour week) to that worker.

d) Meal Breaks

- A worker may not work for more than five hours without taking a meal break of at least thirty minutes duration.
- An employer and worker may agree on longer meal breaks.
- A worker may not work during a meal break. However, an employer may require a worker to perform duties during a meal break if those duties cannot be left unattended and cannot be performed by another worker. An employer must take reasonable steps to ensure that a worker is relieved of his or her duties during the meal break.
- A worker is not entitled to payment for the period of a meal break. However, a worker who is paid on the basis of time worked must be paid if the worker is required to work or to be available for work during the meal break.

e) Special Conditions for Security Guards

- A security guard may work up to 55 hours per week and up to eleven hours per day.
- A security guard who works more than ten hours per day must have a meal break of at least one hour or two breaks of at least 30 minutes each.

f) Daily Rest Period

Every worker is entitled to a daily rest period of at least eight consecutive hours. The daily rest period is measured from the time the worker ends work on one day until the time the worker starts work on the next day.

g) Weekly Rest Period

Every worker must have two days off every week. A worker may only work on their day off to perform work which must be done without delay and cannot be performed by workers during their ordinary hours of work ("emergency work").

h) Work on Sundays and Public Holidays

- A worker may only work on a Sunday or public holiday to perform emergency or security work.
- Work on Sundays is paid at the ordinary rate of pay.
- A task-rated worker who works on a public holiday must be paid:
  - the worker's daily task rate, if the worker works for less than four hours;
  - double the worker's daily task rate, if the worker works for more than four hours.
- A time-rated worker who works on a public holiday must be paid:
  - the worker's daily rate of pay, if the worker works for less than four hours on the public holiday;
  - double the worker's daily rate of pay, if the worker works for more than four hours on the public holiday.

i) Sick Leave

- Only workers who work four or more days per week have the right to claim sick-pay in terms of this clause.

- A worker who is unable to work on account of illness or injury is entitled to claim one day's paid sick leave for every full month that the worker has worked in terms of a contract.
- A worker may accumulate a maximum of twelve days' sick leave in a year.
- Accumulated sick-leave may not be transferred from one contract to another contract.
- An employer must pay a task-rated worker the worker's daily task rate for a day's sick leave.
- An employer must pay a time-rated worker the worker's daily rate of pay for a day's sick leave.
- An employer must pay a worker sick pay on the worker's usual payday.
- Before paying sick-pay, an employer may require a worker to produce a certificate stating that the worker was unable to work on account of sickness or injury if the worker is:
    - absent from work for more than two consecutive days; or
    - absent from work on more than two occasions in any eight-week period.
- A medical certificate must be issued and signed by a medical practitioner, a qualified nurse or a clinic staff member authorised to issue medical certificates indicating the duration and reason for incapacity.
- A worker is not entitled to paid sick-leave for a work-related injury or occupational disease for which the worker can claim compensation under the Compensation for Occupational Injuries and Diseases Act.

j) Maternity Leave

- A worker may take up to four consecutive months' unpaid maternity leave.
- A worker is not entitled to any payment or employment-related benefits during maternity leave.
- A worker must give her employer reasonable notice of when she will start maternity leave and when she will return to work.
- A worker is not required to take the full period of maternity leave. However, a worker may not work for four weeks before the expected date of birth of her child or for six weeks after the birth of her child, unless a medical practitioner, midwife or qualified nurse certifies that she is fit to do so.
- A worker may begin maternity leave:
    - four weeks before the expected date of birth; or
    - on an earlier date:
        - § if a medical practitioner, midwife or certified nurse certifies that it is necessary for the health of the worker or that of her unborn child;
        - § if agreed to between employer and worker; or
    - on a later date, if a medical practitioner, midwife or certified nurse has certified that the worker is able to continue to work without endangering her health.
- A worker who has a miscarriage during the third trimester of pregnancy or bears a stillborn child may take maternity leave for up to six weeks after the miscarriage or stillbirth.
- A worker who returns to work after maternity leave, has the right to start a new cycle of twenty-four months employment, unless the SPWP on which she was employed has ended.

k) Family Responsibility Leave

- Workers, who work for at least four days per week, are entitled to three days paid family responsibility leave each year in the following circumstances:
    - when the employee's child is born;
    - when the employee's child is sick;
    - in the event of a death of:

  - § the employee's spouse or life partner;
  - § the employee's parent, adoptive parent, grandparent, child, adopted child, grandchild or sibling.

l) Statement of Conditions

- An employer must give a worker a statement containing the following details at the start of employment:
  - o the employer's name and address and the name of the SPWP;
  - o the tasks or job that the worker is to perform; and 9
  - o the period for which the worker is hired or, if this is not certain, the expected duration of the contract;
  - o the worker's rate of pay and how this is to be calculated;
  - o the training that the worker will receive during the SPWP.
- An employer must ensure that these terms are explained in a suitable language to any employee who is unable to read the statement.
- An employer must supply each worker with a copy of these conditions of employment.

m) Keeping Records

- Every employer must keep a written record of at least the following:
  - o the worker's name and position;
  - o in the case of a task-rated worker, the number of tasks completed by the worker;
  - o in the case of a time-rated worker, the time worked by the worker;
  - o payments made to each worker.
- The employer must keep this record for a period of at least three years after the completion of the SPWP.

n) Payment

- An employer must pay all wages at least monthly in cash or by cheque or into a bank account.
- A task-rated worker will only be paid for tasks that have been completed.
- An employer must pay a task-rated worker within five weeks of the work being completed and the work having been approved by the manager or the contractor having submitted an invoice to the employer.
- A time-rated worker will be paid at the end of each month.
- Payment must be made in cash, by cheque or by direct deposit into a bank account designated by the worker.
- Payment in cash or by cheque must take place:
  - o at the workplace or at a place agreed to by the worker;
  - o during the worker's working hours or within fifteen minutes of the start or finish of work;
  - o in a sealed envelope which becomes the property of the worker.
- An employer must give a worker the following information in writing:
  - o the period for which payment is made;
  - o the numbers of tasks completed or hours worked;
  - o the worker's earnings;
  - o any money deducted from the payment;
  - o the actual amount paid to the worker.
- If the worker is paid in cash or by cheque, this information must be recorded on the envelope and the worker must acknowledge receipt of payment by signing for it.
- If a worker's employment is terminated, the employer must pay all monies owing to that worker within one month of the termination of employment.

o) Deductions

- An employer may not deduct money from a worker's payment unless the deduction is required in terms of a law.
- An employer must deduct and pay to the SA Revenue Services any income tax that the worker is required to pay.
- An employer who deducts money from a worker's pay for payment to another person must pay the money to that person within the time period and other requirements specified in the agreement law, court order or arbitration award concerned.
- An employer may not require or allow a worker to:
    - repay any payment except an overpayment previously made by the employer by mistake;
    - state that the worker received a greater amount of money than the employer actually paid to the worker; or
    - pay the employer or any other person for having been employed.

p) Health and Safety

- Employers must take all reasonable steps to ensure that the working environment is healthy and safe.
- A worker must:
    - work in a way that does not endanger his/her health and safety or that of any other person;
    - obey any health and safety instruction;
    - obey all health and safety rules of the SPWP;
    - use any personal protective equipment or clothing issued by the employer;
    - report any accident, near-miss incident or dangerous behaviour by another person to their employer or manager.

q) Compensation for Injuries and Diseases

- It is the responsibility of the employers (other than a contractor) to arrange for all persons employed on a SPWP to be covered in terms of the Compensation for Occupational Injuries and Diseases Act, 130 of 1993.
- A worker must report any work-related injury or occupational disease to their employer or manager.
- The employer must report the accident or disease to the Compensation Commissioner.
- An employer must pay a worker who is unable to work because of an injury caused by an accident at work 75% of their earnings for up to three months. The employer will be refunded this amount by the Compensation Commissioner. This does NOT apply to injuries caused by accidents outside the workplace such as road accidents or accidents at home.

r) Termination

- The employer may terminate the employment of a worker for good cause after following a fair procedure.
- A worker will not receive severance pay on termination.
- A worker is not required to give notice to terminate employment. However, a worker who wishes to resign should advise the employer in advance to allow the employer to find a replacement.
- A worker who is absent for more than three consecutive days without informing the employer of an intention to return to work will have terminated the contract.

However, the worker may be re-engaged if a position becomes available for the balance of the 24-month period.

- A worker who does not attend required training events, without good reason, will have terminated the contract. However, the worker may be re-engaged if a position becomes available for the balance of the 24-month period.

s) Certificate of Service

- On termination of employment, a worker is entitled to a certificate stating:
  - the worker's full name;
  - the name and address of the employer;
  - the SPWP on which the worker worked;
  - the work performed by the worker;
  - any training received by the worker as part of the SPWP;
  - the period for which the worker worked on the SPWP;
  - any other information agreed on by the employer and worker.

Appendix 33: GROUP TASK BALANCING

1. Group Task Balancing

a) Group Task for a Construction Operation

A methodology was developed by Little (1993) to enable management to set appropriate group tasks for a set of different activities which together comprise a complex construction operation. This methodology has been modified as follows:

The methodology has several steps:

Step 1: First, separate the individual activities into items which can be related to one another and therefore considered as part of the same team. For example, in relation to cut and fill, he identified two operations (a) transverse cut and fill and (b) longitudinal haul.

Step 2: Identify each activity that is necessary in order to carry out a certain sub-operation by each separate team: A, B, C, N . This would include those activities which were not as clearly definable and measurable on an individual basis. For the example given earlier related to the excavation, load and spread activities of a transverse cut and fill operation, i.e. "setting out", compact by hand rammer, replace top-soil on fill-slope, and replant grass, would now be included. For the transverse cut and fill operation, Little identified 9 activities: cut to stockpile of topsoil; cut to fill transversely in soft, medium and hard material; compact fill by hand rammer; shape camber with templates; shape side drain with templates; replace topsoil on fill slope; replant grass. For the longitudinal haul operation, he identified 5 activities using wheelbarrows: excavate and load in soft, medium and hard material; haul and tip; spread. These activities would be carried out by a separate team.

Step 3: Estimate the amount of each activity which could be carried out by one person during the course of a working day. The daily productivity related to activities A, B, C ... N would be a, b, c ... n.

Step 4: Derive a relationship between the productivity of each activity and the length of the road which could be constructed in one working day if only that activity were concerned. For example:

Gravelling of road : Spread only

Length = L_s
Width = W
Thickness = T

Volume of material spread = $L_s \cdot W \cdot T = s$

$$\therefore s = L_s \cdot W \cdot T$$

$$1 = \left[\frac{L_s \cdot W \cdot T}{s}\right]$$

or $$1 = \left[\frac{L_s}{s/(W \cdot T)}\right]$$

or $$L_s = \frac{s}{W \cdot T}$$

Example: One activity only

Productivity for spreading = s = $12m^3$

Length of carriageway completed = L_s

Width of carriageway = W = 6,00m

Thickness of material = T = 0,10m

$$\therefore W \cdot T = 6{,}00 \cdot 0{,}10 = 0{,}60 m^2$$

Volume of material = $s = L_s \cdot W \cdot T$

$$1 = \left[\frac{L_s}{12/0{,}60} \right]$$

L_s = 20m

Now calculate the length of road constructed in one day using several activities.

For example: starting with three activities A, B and C, the length would be L_{abc}

- For activity A:
  If *a* is produced in 1 day.
  Then $L_{abc} \cdot W \cdot T$ is produced in *x* day.

$$x = 1 \cdot \left[\frac{L_{abc} \cdot W \cdot T}{a} \right]$$

- For activity B:
  If *b* is produced in 1 day.
  Then $L_{abc} \cdot W \cdot T$ is produced in *y* day.

$$y = 1 \cdot \left[\frac{L_{abc} \cdot W \cdot T}{b} \right]$$

$$y = 1 \cdot \left[\frac{L_{abc}}{b/(W \cdot T)} \right]$$

- For activity C:
  If *c* is produced in 1 day.
  Then $L_{abc} \cdot W \cdot T$ is produced in *z* day.

$$z = 1 \cdot \left[\frac{L_{abc} \cdot W \cdot T}{c} \right]$$

$$z = 1 \cdot \left[\frac{L_{abc}}{b/(W \cdot T)} \right]$$

If $x + y + z = 1$ day

$$\therefore \left[\frac{L_{abc}}{a/(W \cdot T)}\right] + \left[\frac{L_{abc}}{b/(W \cdot T)}\right] + \left[\frac{L_{abc}}{c/(W \cdot T)}\right] = 1$$

$$\therefore L_{abc}\left[\frac{1}{a/(W \cdot T)} + \frac{1}{b/(W \cdot T)} + \frac{1}{c/(W \cdot T)}\right] = 1$$

$$\therefore L_{abc} = \frac{1}{\frac{1}{a/(W \cdot T)} + \frac{1}{b/(W \cdot T)} + \frac{1}{c/(W \cdot T)}}$$

For N activities this would be generalised to:

$$\therefore L_{abc...n} = \frac{1}{\frac{1}{a/(W \cdot T)} + \frac{1}{b/(W \cdot T)} + \frac{1}{c/(W \cdot T)} + ... + \frac{1}{n/(W \cdot T)}}$$

Example for three activities:
Width of carriageway = W = 6,00m
Thickness of material = T = 0,10m
Excavation productivity = a = 3m^3/day
Load productivity = b = 6m^3/day
Spread productivity = c = 12m^3/day

$$\therefore L_{abc} = \frac{1}{\frac{1}{3/(6{,}00 \cdot 0{,}10)} + \frac{1}{6/(0{,}60)} + \frac{1}{12/(0{,}60)}}$$

$$\therefore L_{abc} = \frac{1}{\frac{1}{5} + \frac{1}{10} + \frac{1}{20}} = \frac{1}{0{,}35}$$

L_{abc} = 2,86 metres per day.

a) Alternative Calculation Method

One kilometre of gravelling requires $1000 \cdot W \cdot T$ m^3

$\therefore$ Number of days for excavation $= \frac{1000 \cdot W \cdot T}{a}$

$\therefore$ Number of days for loading $= \frac{1000 \cdot W \cdot T}{b}$

$\therefore$ Number of days for spreading $= \frac{1000 \cdot W \cdot T}{c}$

Total days for 1 km $= 1000 \cdot W \cdot T\left[\frac{1}{a} + \frac{1}{b} + \frac{1}{c}\right]$

Length constructed per day $= \dfrac{1000}{1000 \cdot W \cdot T\left[\dfrac{1}{a}+\dfrac{1}{b}+\dfrac{1}{c}\right]} = \dfrac{1}{6{,}00 \times 0{,}10\left[\dfrac{1}{3}+\dfrac{1}{6}+\dfrac{1}{12}\right]}$

$$= \frac{1}{0{,}60 \cdot 0{,}583} = 2{,}86m$$

Generalised to:

Length constructed per day with N related activities

$$\therefore L_{a \ldots n} = \frac{1000}{1000 \cdot W \cdot T\left[\dfrac{1}{a}+\dfrac{1}{b}+\dfrac{1}{c}+\ldots+\dfrac{1}{n}\right]} = \frac{1}{W \cdot T\left[\dfrac{1}{a}+\dfrac{1}{b}+\dfrac{1}{c}+\ldots+\dfrac{1}{n}\right]}$$

or

$$\therefore L_{a \ldots n} = \frac{1000}{1000 \cdot \left[\dfrac{1}{a/(W \cdot T)}+\dfrac{1}{b/(W \cdot T)}+\dfrac{1}{c/(W \cdot T)}+\ldots+\dfrac{1}{n/(W \cdot T)}\right]}$$

$$\therefore L_{a \ldots n} = \frac{1}{\left[\dfrac{1}{a/(W \cdot T)}+\dfrac{1}{b/(W \cdot T)}+\dfrac{1}{c/(W \cdot T)}+\ldots+\dfrac{1}{n/(W \cdot T)}\right]}$$

Which is the same as Little's equation.

Little summarised the issue as follows:

This team task is as complicated a team task as can be imagined in civil engineering. It is a multi-activity task but as has been demonstrated, it is possible to calculate the length of road to be completed by one person in one day, and hence the task for the whole team.

However, he continued: *the calculation procedure is long and involved for the site staff as well as generating lots of paper. Hence it is found to be much better to produce tables of figures as an aid to setting the task*.

Little was writing in the context of low-volume, extremely low-cost access roads. Although he stated that the size of a team would usually be 5 persons; elsewhere team sizes of 15, 25 and larger have been used for low-cost, low-volume road construction. In our experience, it is difficult for one “hands-on'' road-builder/site supervisor to effectively manage more than 25 people unless it is possible to arrange the work in such a way that every group of (at most) 25 workers has its own sub-supervisor, who reports directly to the “hands-on” site supervisor.

Appendix 34: TEAM BALANCING EXERCISE

1. Team Balancing Exercise

The authors developed what they term a team balancing exercise in order to:

- Aid the thinking through of the construction process in relation to the Bill of Quantities, thereby assessing and balancing the workers within and between operations.
- Obtain an estimate of the total number of tasks required to complete a project. This leads directly to estimate of total labour cost.

Comment

- This process reveals a robust estimate of actual labour cost. Whether you like it or not, this is the cost, it is. Where an attempt is made to direct the amount of money spent on labour, “targeted proportions”, all that happens, is that people cook the books to reach the targeted proportions. For example, if the figure is less than, say, the targeted 25 per cent, then the Contractor can achieve this target either by employing more people at a set rate, implying lower productivities, or the same number of people at higher rates of pay.
- A first approximation for the additional cost of “hands-on” site supervisors, who are paid at a different rate, may also be obtained from the estimate of the total number of tasks:

  Total tasks = TT

  Total tasks divided by 10 = TT / 10.

  Labour wage rate = D.

  “Hands on” site management wage rate = SD.

  Additional cost of site supervision = (TT/10) * SD - D.

A Team Balancing Schedule was developed for use in a Team Balancing Exercise.

For the format of the Team Balancing Schedule: refer to Figure 1.

To repeat, this Schedule may be used at various stages of the contract cycle.

- First, during the design and specification phase, use can be made of the Team Balancing Schedule to identify the exact scope for individual tasks and give direction to the compilation of the tender documentation.
- Secondly, tenderers can use a Team Balancing Schedule to calculate their bid.
- Thirdly, contractors can use the Schedule to check and test assumptions made at that time of tender.

	TEAM BALANCING SCHEDULE	(WORKING SHEET)							
	CONTRACTOR								
	PROJECT								
	OPERATION / ACTIVITY	QUANTITY	TASK	No of TASKS	No of WORKERS	DAYS	BALANCE DAYS*	Actual No WORKERS	SUB TOTAL FOR GROUP
		A	B	A/B	D(Est)	E = C/D	F (Actual)	G = C/F	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
			Total No Tasks				Total No. Workers Required		
			Wage Rate						
			Labour Cost	Total Tasks x Wage Rate					
	*Balance Days must be the same for functionally linked operations								
	JAC/EIEC								

Figure 1 Format of Team Balancing Schedule

How to use the form

- Enter the details of the contractor, project, and list all the operations and the activities which are required. These may be the items in the Bill of Quantities or activities which result from an assessment of the actual work breakdown structure which needs to be taken into account in order to generate the items in the Bill of Quantities i.e.. the full list of activities does not necessarily correspond directly to the items in the Bill, because there may be more activities to be analysed than are conventionally measured in a Bill of Quantities.
- In the column marked A enter the quantities of each operation and activity.
- In column B enter the task size i.e. the amount of work which has either been allocated to this type of task, or the amount of work which the tenderer feels can be completed in a single task.
- For each operation calculate the number of tasks which need to be completed by dividing the quantity by the task size (A/B).
- Calculate the total number of tasks required to complete the project (all operations).

- Calculate the direct labour costs by multiplying the number of tasks for the project by the wage rate. **It is necessary to emphaize what should be obvious this is the estimate of the actual labour cost for the project**.
- Estimate the number of workers which could be applied to each activity and operation, bearing in mind other concurrent activities and operations and the overall size of the team. At this stage, the estimate will still be preliminary but will indicate the likely number of days required to complete the project.
- In column E enter the number of days required for each activity or operation, by dividing the number of tasks by the number of workers estimated. This will give an indication of the amount of time required for the activity or operation by comparison with other functionally linked activities that comprise an operation.
- Determine the number of functionally linked balance days i.e. the number of days which could reasonably be allocated to the activities which are functionally linked e.g. excavation, pipe laying and back filling are functionally linked. Since it is not permissible to leave trenches open overnight, these operations must be completed within one day. The number of balance days required for the linked operations within an operation is entered against all of the activities in the operation (F).
- Determine the actual number of workers required to achieve completion of the activities and operations on a task basis within the period selected, by dividing the number of tasks (column C) by the balance days (column F). The number of workers should be rounded to the nearest whole number.
- Total up the number of workers required for each operation and determine the total number of workers required at any one time.

Notes

- Decide if the various functionally linked groups of activities are to be completed simultaneously or sequentially. If they are to be completed simultaneously, then the grand total of the sub totals for each operation, will indicate the size of the team which is required to carry out the contract. If work can be carried out sequentially, then a careful inspection must be made, in an attempt to maintain the size of the workforce and still maintain a balance amongst the different operations. If it is possible to hire and fire workers on a daily basis, then the optimum team size, as determined in accordance with the Team Balancing Schedule for each operation, will determine the work force required on each day.
- If multiple tasking (in other words more than one task per worker per day or per team per day), is allowed, then the necessary adjustments to the probable number of days will be required.
- If the same workers are to compete all activities in an operation, for example excavate, lay pipes and backfill, then the total number of workers required will be determined by the combined productivity for all activities. This approach may best be achieved by the definition of a team task and use thereof to determine the number of days.

An Example of a Team Balancing Exercise

An understanding of the use of a team balancing exercise may be aided by its application to a practical project.

A simple Bill of Quantities has been prepared for a simple project.

The works consists of the construction of a basic sports field at a Department of Education School. A simple Bill of Quantities has been prepared. With the exception of the compaction, (assume a Bomag 80 with a 1.2 metre wide roller), no other mechanical equipment may be used for excavation or for transport. The maximum assumed haul distance is 100 metres.

The following standard tasks sizes have been assumed and prescribed for certain activities.

Excavate: $3{,}00m^3$
Load: $6{,}00m^3$
Haul: $2{,}70m^3$
Extra over hard: $1{,}50m^3$
Spread to line and level: $12{,}00m^3$

ORANGE FARM SCHOOL ACCESS ROADS

ITEM NO	Operation Subop/Activity	Quantity	Task	No.Tasks	No. Workers	Days	Balance Days	Actual No	Sub total No Workers
		A	B	C=A/B	D(est)	E=C/D	F(actual)	G=C/F	
1.0	Setting Out	Lump Sum			3.0				3.0
2.0	ELHS and Compact								
2.1	Excavate	13000.0	3.0	4333.3	80.0	54.2	60.0	72.2	
2.2	E/O Hard	4000.0	1.5	2666.7	10.0	266.7	60.0	44.4	
2.3	Load	13000.0	6.0	2166.7	40.0	54.2	60.0	36.1	
2.4	Haul	13000.0	2.7	4814.8	40.0	120.4	60.0	80.2	
2.5	Spread	13000.0	12.0	1083.3	20.0	54.2	60.0	18.1	
2.6	Compact	11000.0	1000.0	11.0	2.0	5.5	60.0	0.2	
								251.3	251.3
	Totals			15075.8					254.3
	Wage Rate(say)			70.0					
	Labour Cost			1055307.0					

Appendix 35: SPREADSHEET ANALYSIS

The spreadsheet version uses a percentage labour force of the total man. days required to complete the works. The analysis was done at two levels, one where the actual construction process was taken into account and the second where the construction of shoulders by labour was considered. The production rates outlined in Table 1 were used in the analyses. A detailed explanation of the procedure is given below.

Table 1 Level 1 – The actual construction operations taken into account

Item	Operation	Quantity of work
1	Shuttering	25 329m
2	Aggregate placing	8 443m
3	Level Check	8 443m
4	Application of fines	25 329m
5	Slushing	8 443m

Table 2 contains the results obtained from the above analysis.

Table 2 Proposed team balancing schedule for WBM base course construction at Matoks at PPR based on actual construction procedure.

OPERATION		Shuttering	Aggre-gate	Level check	Appli-cation	Slush-ing	TOTALS	Time: days	Mdys balance	Cost Balance
Length for each operation (m)		25 329	8 443	8 443	25 329	8 443				
Production rates:		58	5.7	83	26	35				
Labour in one day	(-)	437	1 480	102	974	241	**3 235**			
Percentage of total:		13%	46%	3%	30%	7%	**100%**			
Team size:	**20**	2.70	9.16	0.63	6.02	1.49	**20**	162	*3 235*	*70 589*
	30	4.05	13.74	0.94	9.03	2.24	**30**	108	*3 235*	*70 589*
	40	5.40	18.31	1.26	12.05	2.98	**40**	81	*3 235*	*70 589*
	50	6.75	22.89	1.57	15.06	3.73	**50**	65	*3 235*	*70 589*
	60	8.10	27.47	1.89	18.07	4.47	**60**	54	*3 235*	*70 589*
	70	9.45	32.05	2.20	21.08	5.22	**70**	46	*3 235*	*70 589*
	80	10.80	36.63	2.52	24.09	5.97	**80**	40	*3 235*	*70 589*
	90	12.15	41.21	2.83	27.10	6.71	**90**	36	*3 235*	*70 589*
	100	13.50	45.79	3.14	30.11	7.46	**100**	32	*3 235*	*70 589*
	110	14.85	50.37	3.46	33.12	8.20	**110**	29	*3 235*	*70 589*
	120	16.20	54.94	3.77	36.14	8.95	**120**	27	*3 235*	*70 589*
	130	17.55	59.52	4.09	39.15	9.69	**130**	25	*3 235*	*70 589*
	140	18.90	64.10	4.40	42.16	10.44	**140**	23	*3 235*	*70 589*
	150	20.25	68.68	4.72	45.17	11.18	**150**	22	*3 235*	*70 589*

It must be noted that the number of labourers obtained from the above analysis for each work item must be rounded off to the nearest or best possible whole number. The above system is just a guide to make it easier for the team balancing exercise to be carried out.

If the parameters for the sports field example were altered to:
Excavate: 3,20m^3
Load: 7,50m^3
Haul: 2,70m^3
Extra-Over Hard: 2,20m^3
Spread to line and level: 14,00m^3

We then obtain the following (Table 3):

Table 3 Combining a team balancing exercise with a size of team/length of time table

Operation	Set out	Excavate Load Haul and Spread						Totals	Total mdys	Project Days
Item	1.0	2.0								
Item No.		2.1	2.2	2.3	2.4	2.5	2.6			
Description		Exc	E/O Hard	Load	Haul	Spread	Compact			
Quantity	Lump Sum	13000.0	4000.0	13000.0	13000.0	11000.0	13000.0			
Task		3.2	2.2	7.5	2.7	14.0	100.0			
No.of Tasks	6.0	4062.5	1818.2	1733.3	4814.8	785.7	130.0	13344.5		13344.5
%	0.0	30.4	13.6	13.0	36.1	5.9	1.0	100.0		
Team Size								Team Size		
20.0	0.0	6.1	2.7	2.6	7.2	1.2	0.2	20.0	13344.5	666.9
40.0	0.0	12.2	5.4	5.2	14.4	2.4	0.4	40.0	13344.5	333.5
60.0	0.0	18.3	8.2	7.8	21.6	3.5	0.6	60.0	13344.5	222.3
80.0	0.0	24.4	10.9	10.4	28.9	4.7	0.8	80.0	13344.5	166.7
100.0	0.0	30.4	13.6	13.0	36.1	5.9	1.0	100.0	13344.5	133.4
120.0	0.1	36.5	16.3	15.6	43.3	7.1	1.2	120.1	13344.5	111.2
140.0	0.1	42.6	19.1	18.2	50.5	8.2	1.4	140.1	13344.5	95.3
160.0	0.1	48.7	21.8	20.8	57.7	9.4	1.6	160.1	13344.5	83.4
180.0	0.1	54.8	24.5	23.4	64.9	10.6	1.8	180.1	13344.5	74.1
200.0	0.1	60.9	27.2	26.0	72.2	11.8	1.9	200.1	13344.5	66.7
220.0	0.1	67.0	30.0	28.6	79.4	13.0	2.1	220.1	13344.5	60.6
240.0	0.1	73.1	32.7	31.2	86.6	14.1	2.3	240.1	13344.5	55.6
260.0	0.1	79.2	35.4	33.8	93.8	15.3	2.5	260.1	13344.5	51.3
280.0	0.1	85.2	38.1	36.4	101.0	16.5	2.7	280.1	13344.5	47.6
300.0	0.1	91.3	40.9	39.0	108.2	17.7	2.9	300.1	13344.5	44.5