LABOUR-BASED TECHNOLOGIES AND METHODS FOR EMPLOYMENT INTENSIVE CONSTRUCTION WORKS

BEST PRACTICE GUIDELINE 1

An Overview of Labour-Based Technologies and Methods in Employment Intensive Works

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1 Background

Engineers have traditionally used their skills and expertise to ensure that structures or structural components are serviceable and durable in addition to possessing adequate strength and stability. A well designed structure is, normally, considered to be one which meets these requirements in the most economically efficient manner, least cost being the measure of value for money. Engineers similarly design services using the same approach. In recent years, however, the term "value for money" has in South Africa been broadened to take cognisance of socio-economic and political benefits. Government has realised that there is a cost to unemployment and poverty and that there is a price to be paid for the economic empowerment of marginalised communities. Accordingly, value for money is now assessed in a revised context.

There are definite relationships between employment opportunities, available skills, entrepreneurship and the use of small scale enterprises in the creation and maintenance of assets. The construction strategies that are adopted can be used to address social and economic needs and concerns and, depending upon how they are structured, to facilitate the economic empowerment of marginalised sectors in a focussed manner. Thus, the process of constructing assets can be just as important as the provision of the assets themselves.

Projects involving the creation of assets can also promote sustainable community development should they be structured so as to:

- create employment opportunities;
- promote community involvement;
- impart technical skills to the unskilled and semi-skilled members of the community;
- transfer administrative, commercial and managerial skills to the community;
- retain, as far as is possible, the funds expended on the project within the community; and
- develop contractors from within the community in which they are to be constructed.

Projects that address these objectives allow the resources of the community to be built up in an endogenous manner, i.e., to be grown from within.

The Green Paper on Public Sector Procurement Reform in South Africa (1997) suggests that Procurement should facilitate the generation of jobs in South Africa by:

- ensuring that the foreign content in contracts involving goods, services and works is minimised.
- encouraging the substitution of labour for capital.
- supporting the use of “labour friendly” technologies which utilise a higher degree of labour input than is the case for conventional technologies, or are well suited to implementation by small scale enterprises.

- encouraging and developing small scale enterprises to implement employment intensive practices and "labour-friendly" technologies.

All of the above presupposes that appropriate labour-based methods and technologies are readily available to those engaged in construction works as designers and constructors.

2 The employment potential of construction projects

2.1 An overview

Expenditure in any sector of the economy will create employment opportunities. Some sectors of industry are, however, more efficient than others at generating employment opportunities for a given capital inflow. Industries where the potential for the effective substitutions of labour for capital and local resources for imports exist, can expect to achieve enhanced performance in the provision of employment opportunities. The construction industry is an industry that may be regarded as being amongst the most efficient in generating employment for a given capital inflow.

The Green Paper on an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry (1997) suggests that the construction industry in 1997 could generate between 11 and 23 direct, indirect and derived jobs per million Rand invested in the different sectors of the industry. (Average of approximately 17 jobs per million Rand invested). It points out, however, that although these figures are slightly higher than other industrial sectors they do not justify infrastructure investment beyond the immediate requirements in order to create jobs. If, however, the number of jobs created can be increased for example by substituting people for machines, investment in infrastructure projects will become more attractive.

Employment-intensive works have been highly visible in the civil engineering sector. The civil engineering sector is plant-intensive when compared to the building sector. The building sector, in general, generates more employment opportunities per unit of expenditure than does the civil engineering sector. If, however, labour is substituted for machines, this position can be reversed. Alternatively, if a blend of labour and light equipment is used on civil engineering projects, the difference in labour-intensiveness between the two sectors reduces.

Several employment-intensive works programmes have been implemented in Africa and Asia over the last two decades. These labour and resource based programmes have aimed to serve several purposes simultaneously. Above all they have aimed to influence infrastructure investment policies so as to maximise employment and income generation, the creation of productive assets and poverty alleviation.

Employment-intensive methods have been employed in South Africa on construction projects which include rural gravel roads; low level bridges; small dams; residential township roads (surfaced and gravel); water and sewerage reticulation for townships; bituminous surfacing of roads; low voltage electrical reticulations; stormwater drainage systems; and on-site sanitation. Road maintenance projects have included regravelling, and routine road maintenance.

Other employment-intensive construction-related projects have included materials manufacture (precast concrete products, timber roof trusses, metal window frames); agricultural structures (dams, erosion control measures, irrigation projects); building works (community centres, clinics, schools, classrooms, housing); and electrification.

2.2 Quantitative information on the potential of labour-based technologies and methods[1]

The authors of a report commissioned in 1994 by the National Housing Forum in South Africa, suggested that there are a number of ways in which employment opportunities in the provision of housing and related infrastructure can be maximised. These relate to forms of construction, construction methods, and manufacturing methods.

1 Refer to Appendix 1 for tabulations of quantitative data obtained from a number of local and international publications.

They recognised that in order to achieve the goal of maximising employment opportunities, quantitive information needed to be made available to developers, architects, engineers and the like as to which technologies, construction methods, materials etc. would be likely to promote high employment. Employment opportunities in the construction of the built environment, i.e., houses, amenities and infrastructure, were examined in some detail in this National Housing Forum study. Manufacturers and producers of a wide range of construction materials were approached to provide information regarding the number of person hours required to produce their products. It appeared logical that this figure should include all the time spent on obtaining raw materials, manufacturing of the item and stockpiling the item prior to distribution and could be based on the total number of person hours worked in the industry (management, administrative staff, workers etc.) and the quantity of the item produced. Some of the results of this survey are summarised in Table 1. The researchers, using the CSIR Division of Building Technology's Housing Delivery Systems Analysis (HDSA) database, were able to estimate the number of person hours required to construct a masonry house for any given floor plan. In this manner, they were able to compare the total number of person hours required to construct houses using different forms of construction (see Table 2). They suggested that employment opportunities should be linked to cost to ensure that sector effectiveness and efficiency were not impaired. Table 3 compares the cost per person hour generated for the different forms of house construction presented in Table 2.

Table 1 : Approximate number of person hours required to manufacture some building and construction materials

ITEM	DESCRIPTION	UNIT	PERSON HOURS PER UNIT
Aggregate	- sands for mortar, plaster and subbase material	ton	0,12
	- stone for concrete, waterbound macadam; and road bases	ton	0,27
	- transport (20 km haul)	ton	0,13
Bitumen	- road grade	ton	0,7
Cement	- OPC	ton	1,1
Clay sewer pipes	- 150 m diam	100 m	68,2
	- 150 x 150 junction	1	0,9
Clay masonry units	- 106 x 212 x 73 (high-tech plant)	1 000	3
	- 106 x 212 x 73 (normal plant)	1 000	9-9,5
Concrete masonry units	- 140 mm hollow (plant manufacture)	10 m2	5,6-8,2
	- 140 mm hollow (hand manufacture)	10 m2	22,4
Concrete paving units	- 65 mm thick (plant manufacture)	10 m2	3,6-4,1
Concrete pipes	- 450 mm dia	100 m	100
	- 600 mm dia	100 m	125
Concrete roof tile		10 m2	0,9
Door frames	- standard pressed metal	1	0,5
FC Roof sheeting		10 m2	4,1
FC Ceiling board		10 m2	1,9
FC sewer pipe	- 150 mm dia	100 m	23
Gate valve	- 80/90 mm dia RSV	1	2,0
Glass	- 3 mm float	100 m2	4,2
Gypsum ceilings		10 m2	3,3
HDPE pipe	- 32 mm dia (water)	100 m	3
Paint	- PVA	100 litre	5
Polyethylene	- pipe grade	ton	3,3
Polypropylene	- pipe grade	ton	5,2
Precast concrete products	- average	ton	7,8
Steel roof sheeting	- 0,6 mm galvanised	ton	21,1
Steel sections	- commercial grade angles, channels and IPEs	ton	10,1
Timber	- structural grade	m3;	19,6
uPVC pipes	- 160 mm dia (sewer, HD)	100 m	30
Window frames	- ND54	1	1,3
	- NC1	1	0,8

Table 2 : Comparison of the number of person hours required to construct non-masonry and masonry houses

CONSTRUCTION TYPE	NUMBER OF PERSON HOURS (hours) (NON MASONRY)			NUMBER OF PERSON HOURS FOR EQUIVALENT MASONRY HOUSES (hours)		
	MATERIALS	SITE LABOUR	TOTAL	MATERIALS	SITE LABOUR	TOTAL
Timber (SALMA)	300	1 180	1 480	200	1 700	1 900
Precast concrete panels and posts (Blitz)	150	210	360	120	1 120	1 240
Steel frame with 110 mm brick infill panels (Belaton)	330	880	1 210	160	1 400	1 560

The researchers demonstrated how similar statistics could be generated for the provision of township services. Table 4 presents such statistics for the servicing of stands in a specific low-cost housing development in South Africa (typical electrification costs are included for comparative purposes). Table 5 presents statistics relating to the potential in roadwork activities. Person hours associated with the excavation of trenches using labour-based construction methods, based on statistics derived from Soweto's Contractor Development Programme, were then substituted for those associated with plant-based construction. The implications of using these construction methods are reflected in Table 6.

Table 3 : Evaluation of non-masonry house types

CONSTRUCTION TYPE	ESTIMATED COSTS (1994) (Rand)		COST/PERSON HOUR (Rand/person hour)	
	NON-MASONRY	MASONRY EQUIVALENT	NON-MASONRY	MASONRY EQUIVALENT
Timber (SALMA)	47 200	46 100	32	24
Precast concrete panels and posts (Blitz)	16 000	20 300	44	16
Steel frame with 110 mm brick infill panels (Belaton)	28 400	30 800	23	20

Table 4 : Person hours required in the provision of infrastructure for a low cost township using conventional construction methods

SERVICE	ESTIMATED PERSON HOURS (%)		ESTIMATED TOTAL NUMBER OF PERSON HOURS/ERF	COST/PERSON HOUR (Rand/person hour) (March 1992)
	MATERIALS MANUFACTURE	SITE LABOUR		
Water	13	87	39	20
Sewerage	16	84	43	14
Roads (low standard)	14	86	21	36
Stormwater	8	92	26	16
Electricity	70	30	117	20

Table 5: The employment potential of various roadwork activities

ACTIVITY	THICKNESS (mm)	PERSON HOURS TO PRODUCE AND CONSTRUCT (person hours/m^2)	
		PLANT-BASED	LABOUR-BASED
Road bed preparation (R&R)	-	0,033	0,350
Gravel wearing course (G5)	125	0,160	1,000
Gravel wearing course (G4)	150	0,192	1,200
Base course (G4)	150	0,192	1,200
Base course (G3)	125	0,165	NA
Subbase (G6)	150	0,192	1,200
Waterbound macadam base course	100	1,040	1,370
Slurry	15	0,110	2,011
Asphalt	25	0,140	1,170
Concrete blocks	60	0,930+	2,120#
Cast insitu (plastic cell) blocks	-	0,38	1,80

\+ Factory produced block paving
\# Blocks manufactured on site using employment-intensive methods

Table 6: Provision of water and sewer reticulation in a housing development using labour-based methods of construction

SERVICE	LABOUR PERSON HOURS/ERF		COST/PERSON HOUR Rand/person hour) (March 1992)	
	Plant-based	Labour-based	Plant-based	Labour-based
Water	39	58	20	14
Sewerage	43	72	14	9

An analysis of Soweto's Contractor Development Programme, a programme which embraced labour-intensive methods and labour-based technologies and trained and encouraged the community to participate in the managerial, commercial and administrative aspects of construction, revealed some interesting statistics some of which are set out in Tables 7 to 9. The programme generated employment at a cost of approximately R18 /person hour, whereas the average cost for the civil engineering industry in South Africa during the study period amounted to approximately R37-50 /person hour.

Table 7 : Estimated number of person hours generated in Soweto's Contractor Development Programme

TYPE OF CONSTRUCTION	UNIT	ESTIMATED NUMBER OF PERSON HOURS/UNIT (hours/unit)			
		MATERIALS	SITE LABOUR	MANAGEMENT	TOTAL
Road construction (waterbound macadam + stormwater)	m2	0,5	6,8	1,8	9,1
Road construction (concrete block paving) + stormwater)	m2	0,7	8,0	1,8	10,5
Secondary Water Mains	m	0,4	5,9	0,9	8,2
House Connection	erf	0,6	31,4	6,0	38,0

Table 8 : **Expenditure per unit of employment generated in Soweto's Contractor Development Programme**

TYPE OF CONSTRUCTION	UNIT	ESTIMATED EXPENDITURE/PERSON HOUR (Rand)
Road construction (waterbound macadam)	m2	17,9
Road construction (concrete block paving)	m2	18,4
Secondary Water Mains	m	17,4
House connections	erf	17,1

Table 9 : **Percentage of construction cost retained by the community in Soweto's Contractor Development Programme**

DESCRIPTION	ROAD CONSTRUCTION	SECONDARY WATER MAINS	HOUSE CONNECTIONS (PLUMBING)
Labour contract	26	22	33
Transport	2	8	9
Materials Management	2	3	2
Construction Management	7	6	6
TOTAL	37	39	50

2.3 The impact of choice of technology and construction methods on employment

An examination of Tables 3 to 8 indicates that the choice of technology has a marked influence on the number and location of employment. For example, a masonry house may generate 3,5 times more person hours of employment than an equivalent precast concrete house. The same precast concrete house may, however, generate 1,25 times more person hours of employment in the manufacture of materials than the masonry equivalent.

The choice of construction method can, particularly in the case of civil engineering projects, significantly influence the total number of person hours of employment generated. The construction of conventional masonry housing units, depending upon the standards adopted, realises approximately 50% more employment opportunities per unit of expenditure than plant-based servicing of sites. If, however, sites are serviced using labour-based construction practices, without increasing the total construction cost, this is 50% more effective than the construction of masonry housing units in creating employment opportunities.

The choice of manufacturing method of construction components can also significantly affect the number of employment opportunities generated. For example, the ratio of person hours employment generated in conventional construction on-site to that generated in the conventional off-site manufacture of the associated materials is 9 : 1 for house construction and 6,5 : 1 for township services (roads, stormwater drainage, water supply and sewerage). There is, clearly, considerable scope for increasing employment opportunities through the use of employment-intensive methods of manufacture of materials.

Changes in methods and technologies, which increase the labour content of construction and the manufacture of materials, can yield increases in the number of employment opportunities generated per unit of expenditure. This however, requires large, well established companies to change their work methods and reduce their reliance on capital intensive technologies; a difficult task. In contrast, small scale enterprises, who, being small, have limited access to capital and invariably operate and conduct their businesses in a more employment-intensive fashion and favour light equipment-based forms of construction, would have little difficulty in adopting new methods and technologies.

Recent research in South Africa has indicated that, provided there is little or no cost premium associated with employment intensive practices, the overall increase in employment opportunities for a given project over conventional plant-based practices may reach a factor of 2 in urban infrastructure and 3 in rural road construction; increases which are extremely valuable.

3 The impact of the choice of technology

The choice of technology not only influences employment parameters, as previously described, but determines who is able to participate in a project. The following two examples on the impact of technology choices illustrate this.

In the first example, a church community wished to construct a 600 m^2 church hall on a site where moderately expansive clays were present. A member of the congregation, who had recently been made redundant, volunteered to construct the building on a labour only basis. He had some building experience and had access to some bricklayers and a small truck and trailer. In addition, he had the necessary commercial credibility to hire any minor equipment which he required.

The builder did not, however, have access to carpenters capable of constructing forms for reinforced concrete work. Nor did he own any formwork or have the experience to supervise reinforced concrete works. So, if the hall had been designed as a reinforced concrete framed building, he could not have constructed it and the church would have had to look outside their congregation for someone to construct the hall.

To accommodate the builder, the hall was designed as a reinforced masonry structure. Reinforcement was placed in masonry columns and bedjoints, and fabric reinforcement in cavity walls. Using this form of construction, no formwork was required and the builder was able to use his bricklayers to construct the entire structure. The form of construction proved to be very cost effective, particularly in view of the founding conditions.

In the second example, a rural community was allocated funds for the construction of school classrooms and toilet blocks, the intention being that the community, with appropriate management and technical support, would itself undertake the construction. Most of the structures were located on expansive clay and total surface movements of approximately 50 mm were predicted. Typically, structures built on sites of this nature in South Africa are founded on stiffened reinforced concrete rafts, or on piles. The community simply did not have the skills necessary for these forms of construction.

Alternative solutions were sought. A cellular raft (Boucell, i.e., a foundation system which comprises two horizontal fabric reinforced slabs interconnected by a series of web beams) was finally decided upon. This system did present a few construction challenges that required some innovation to overcome. Old tyres that were obtained at no cost, filled with soil were used as void formers. Masonry was used to create a perimeter beam. (As the width of an average tyre is 170 mm, this solution enabled a course height of 85 mm to be maintained in the structure). The space at the centre of four adjoining tyres proved ample for the placing of shear links. The rafts were readily and economically constructed by the community.

Sometimes it is more appropriate to look to old technologies rather than to attempt to optimise current technology. In Zimbabwe and South Africa, rubble masonry, an old technology that was investigated by 19th century engineers has been resurrected. Rubble masonry is a building material comprising uncut stones bound together with cementitious mortar. Several small dams and bridges have recently been constructed at considerably lower costs than conventional alternative designs. The advantages of using this employment intensive technology instead of conventional alternatives, include the following:

- The only material purchased is cement
- The acquisition costs of sand and stone, sourced in close proximity to the site, are limited to wages for the gatherers and any blasting of rock which may be necessary.
- Transportation costs are minimised, as cement which accounts for approximately 7% of the mass of the rubble masonry structure is the only material which is hauled any significant distance.

- Rubble masonry requires no vertical formwork to contain it during placement.

This technology has not only increased employment opportunities per unit of expenditure, but has also afforded unskilled people, who live in close proximity to the projects, access to employment opportunities in Contractor development in the roads sector can be viewed as a function of the mechanisation level of the contractors as illustrated in Figure 1. As contractors master technologies that make use of light plant, they can purchase and acquire increasingly more costly plant and transform their businesses into fully mechanized ones.

Figure 1: Mechanisation level of some labour-intensive construction techniques

Construction technique	Level of Mechanisation	Discussion
Crushed Stone / Cemented	High	▪ Machine intensive
100 – 150mm water-/dry bound Macadam	High	• Heavy (12 ton) roller required. • Density specification to be met. • Light surfacing types (seals) not recommended.
Foam gravel bases	High	• Graded material to be compacted to specification. • Mechanical mixing often introduced.
100 – 150mm composite Macadam	Medium	Heavy (12 ton plus) roller required. Density specification to be met.
Emulsion treated bases	Medium	• Graded material to be compacted to specification. • Mechanical mixing often introduced.
Concrete Interlocking blocks	Medium	Manufacturing considered mechanised.
75mm composite Macadam	Low	Only light pedestrian rollers required. "Orientation of aggregate sufficient.
Slurry-bound Macadam	Low	Only light pedestrian rollers required. "Orientation" of aggregate sufficient.
Direct labour	Entry point	Entry point

4 Implementation mechanisms

4.1 Overview

In several countries in Africa and Asia long term national programmes of labour-intensive road construction and maintenance have been established. These national programmes have resulted in the creation of employment and the efficient production of as good a quality of construction and maintenance as is allowed by the funding available. This has usually, however, been executed on a pilot project basis. These programmes have resulted in the development and establishment of the skilled personnel required to supervise the site works, to liase with the beneficiary communities and to plan and administer these programmes.

The World Bank in a paper on expanding labour based methods in road works (1996) has identified six basic delivery/implementing mechanisms, viz.:

I The **force account model** ("in house" workforce) whereby a government body hires labour directly (either as individual workers or as worker teams) and provides the necessary supervision, administration and management required to execute the works.

II The **conventional model** whereby a conventional contractor hires labour directly and provides the supervision, administration and management required to execute the works.

III The **sub-contracting model** whereby a large contractor or firm sub-contracts the portions of the projects that are labour-based to small contractors and assumes overall responsibility for the supervision, administration and management required to execute the works.

IV The **government-run** model whereby the responsibility for all aspects of contractor development, including small contractor administration and payment, and the overall responsibility for the supervision, administration and management required to execute the works, lies with a government agency.

V The **agency model** whereby the responsibility for all aspects of contractor development including small contractor administration and payment and the overall responsibility for the supervision, administration and management required to execute the works, lies with an independent non-profit management agency or with a for-profit consulting firm.

VI The **development team model** whereby the responsibility for all aspects of contractor development and the management of the works is divided amongst the Client Body (Employer), a Construction Manager and a Materials Manager.

Models II and III promote the use of labour-based construction practices amongst established contractors; models IV to VI promote the expansion of such methods among small-scale contractors. Model V is commonly encountered in French speaking nations in West Africa where it is referred to as the Agetip model (non-profit contract management agency). Generally, model IV involves fixed rate contracts. Model VI was developed in South Africa and pioneered through Soweto's Contractor Development Programme. It is sufficiently flexible to be used either to develop and support small scale contractors, particularly in the early stages of their development, or to implement "labour pool worker programmes" in the same manner as is done in the force account model, but with private sector firms (construction or consulting) assuming responsibility for the supervision, administration and the management of the labour, and the risk of cost overruns or failure to achieve the required quality or programme objectives being shared between the parties.

In force account operations (Model I), government has direct control over the outcomes of employment-intensive projects and is at risk for any failure to achieve programme objectives. The Government's control over the works in all the other models is, however, diminished. Its risk of failure in these models is reduced, the extent of which is dependent upon the model which is selected. The total project costs of each of the models which involve the private sector is in turn directly related to how risk is managed and assigned to the contracting parties and the nature and complexity of the work involved.

4.2 The engagement of small scale contractors in construction contracts

Construction can be regarded as the synthesis of the following:

- Construction management
- Materials management
- Materials supply
- Plant and equipment
- Labour

Employment-intensive construction is by nature management-intensive and requires that all the aforementioned functional activities be addressed in a project. This is true irrespective of whether or not the construction work is executed by means of force account or large or small scale contractors. Contractors, as is the case with labour units established within governmental agencies, need to have administrative, managerial and technical skills. In addition contractors, if their businesses are to be sustained, need to have commercial skills. Small contractors, particularly newly established businesses, frequently have limited skills and are unable to control cost, time and quality on their projects. Models IV to VI are structured to address these problems.

Numerous pilot projects in a number of countries, using the abovementioned implementation methods, have demonstrated that providing adequate controls and management are put in place, direct labour and small scale contractors can successfully execute labour-based/employment-intensive projects. The challenge, however, lies in expanding these pilot projects into major programmes which can make a significant impact on the employment problem or program objectives.

Many of the aforementioned models attempt to develop small scale contracting capacity to effect employment-intensive works that may previously have been executed using the force account model. Frequently the development of small scale enterprises is seen as a means of expanding programmes in a manner which reduces the management, supervisory and administrative burden placed on government's in-house resources and the risk exposure of cost overruns on programmes.

The quantum of work which can be executed by small contractors in terms of models IV to VI on works of a relatively complex nature, or which have significant specialist or high equipment components, is limited as the breaking down of projects into small contracts is not always justifiable from either a cost or management point of view owing to:

- the division of responsibilities, interdependence of activities, programming, duplication of establishment charges and utilisation of resources
- the lack of skilled management resources;
- the general lack of commercial skills in small scale enterprises; and
- the increased administration of such contracts by public bodies and their agents.

As a result, the use of large scale contractors to engage more labour or to subcontract to small scale contractors has been reconsidered. Unfortunately, onerous conditions have frequently been imposed on contractors which in many instances has impaired their performance and ability to efficiently and effectively deliver infrastructure. This has often translated into increased construction costs and a concomitant erosion of the total volume of potential employment which can be realised through construction projects. In extreme cases, conventional equipment-based construction may have yielded more employment opportunities for the same amount of expenditure.

4.3 Targeted Procurement Procedures

The conventional approach which has generally been adopted in Models II and III has accordingly needed to be re-engineered. An innovative new approach to procurement which addresses the current short comings of Models II and III has been developed in South Africa, viz Targeted Procurement. Targeted Procurement enables Models II and III to be efficiently and effectively implemented with minimal interference on a contractor’s ability to perform. (See Appendix 2)

4.4 Increasing employment opportunities generated per unit of expenditure

Two alternative procurement approaches to implementing employment-intensive works methods can be adopted:

Method 1: Lay down the use of specific employment-intensive technologies and methods of construction/manufacture in the tender document (a variation to this approach is to specify the minimum amount of wages which are required to be paid in respect of a particular contract);

Method 2: Afford tenderers the opportunity to choose the technology/construction method/method of materials manufacture which they wish to use in order to maximise the participation of labour in construction works and in so doing win bids.

Suitable resource specifications can be used in both methods to ensure that the deliverables are attained. Either method may be used to increase the quantity of employment generated per unit of expenditure. Method 1 achieves this objective by restricting the use of certain types of plant/manufacturing methods and by specifying particular technologies. Method 2 (i.e. the Targeted Procurement approach), on the other hand, by means of development objective/price mechanisms and resource specification, enables tenderers to tender the amount of targeted labour, which they undertake to engage in the performance to the contract. Method 2, accordingly, permits tenderers to use their knowledge, skill and creativity in arriving at an optimum economic mix of equipment, technology and labour in order to meet objectives and win bids.

The economic viability of Method 1 is, however, dependent on the ability of the designer/specifier to forecast cost. Any potential price premium in Method 2 can be readily assessed during the adjudication of bids. Method 2 therefore has the distinct advantage that bid prices will usually fall within acceptable limits and economic justification of decisions relating to employment generation will not be necessary.

The Green Paper on Public Sector Procurement Reform in South Africa in this regard proposes the following:

- *A distinction should be made in the targeting of local labour in order to stimulate local economies and the increase in employment opportunities generated per unit of expenditure. Increased credits in development objective / price mechanisms should be granted to encourage the increase in employment opportunities generated per unit of expenditure where tenderers are permitted to choose technologies and work methods.*

- *Any premiums to be paid in respect of employment-intensive practices should be determined and accepted prior to the award contracts. Employment intensive practices should result in the generation of jobs as opposed to the displacement of jobs.*

The Interministerial Task Team for Construction Industry Development in their Recommendations on Refinements in Public Sector Procurement Policy, Practices and Procedures in the Construction Sector reinforce the green paper proposals, viz:

- *Procurement in engineering and construction works should facilitate the generation of jobs in South Africa by:*
  - *encouraging the substitution of labour for capital;*
  - *supporting the use of "labour friendly" technologies which utilise a higher degree of labour input than is the case for conventional technologies, or are well suited to implementation by small scale enterprises; and*
  - *encouraging and developing small scale enterprises to implement employment-intensive practices and "labour-friendly" technologies.*

- *Targeted Procurement should be used to encourage cost effective employment-intensive practices.*

- *Any premiums to be paid in respect of employment-intensive practices should be determined and accepted prior to the award of contracts. Employment intensive practices should result in the generation of jobs as opposed to the displacement of jobs.*

Appendix 2 provides guidance on the use of Targeted Procurement Procedures on infrastructure projects to increase employment per unit of expenditure. It should be noted in this regard that SANS 1914-5 (Participation of Targeted Labour) can be used to measure the nature and quantum of employment used in both of the aforementioned procurement approaches to implementing employment-intensive works. SANS 1921-5 (Earthworks activities which are to be performed by hand) identifies earthworks activities and sub-activities which the contractor must executed by hand, can be used to readily describe the scope of work in a contract which is be executed using Method 1.

5 Selected specialist and related literature

1. Standards South Africa: SANS 1914: *Targeted construction procurement*
   Part 1:Participation of targeted enterprises
   Part 2: Participation of targeted partners in joint ventures
   Part 3: Participation of targeted enterprises and targeted partners in joint ventures
   Part 4: Participation of targeted enterprises and targeted labour (local resources)
   Part 5: Participation of targeted labour

2. Standards South Africa: SANS 10396: *Implementing Preferential Construction Procurement Policies using Targeted Procurement Procedures*

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Note: The International Labour Organisation has a publication which catalogues a number of key publications which may be obtained from their ASIST Information Service entitled "*The Labour-Based Technology Source Book*" (see www.ilo.org/asist for further particulars)

Appendix 1: Quantitative Employment Data on selected Construction Activities

List of tables

A: HOUSING AND RELATED INFRASTRUCTURE

Source: **Watermeyer and Band's National Housing Forum Report (1994) on the Development of Small Scale Enterprise, Skills, Entrepreneurship and Employment Opportunities through the Provision of Housing (see www.targetedprocurement.com)**

B: MINIMUM PRODUCTIVITY LEVELS

Source: **Notice in terms of Section 70(2) of the Labour Act, 1992. Agreement on conditions of employment entered into between the Metal and Allied Namibian Works Union and the Construction Industries Federation of Namibia 6 April 2000, Government Gazette 31 May 2000 (No. 2340).**

No Tables

C: ESTIMATED PRODUCTION RATES FOR CONCRETE BLOCK PAVING

Source: **A Nkambule: A review of Labour Intensive Concrete Block Paving van Wyk andLouw Inc.**

D: CONCRETE MASONRY GRAVITY DAMS CONSTRUCTION

Source: **King CD. Employment creation through the design and construction of medium sized concrete masonry gravity dams in South Africa using Labour-based construction methods: A comparison of alternative technologies. A project report submitted to the faculty of engineering, university of the Witwatersrand, Johannesburg in partial Fulfillment of the requirements for the degree of Master of Science in engineering Johannesburg, 1994.**

Table D1: Balfour dam: Productivity figures for required construction activities

E: EXCAVATION

Source: **A critical analysis of the community-based Public Works Programme in South Africa. A discertation submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in fulfillment of the requirements for the degree of Master of Science in Engineering, Johannesburg, July 1996**

Table E1: Productivity data for excavation by hand

F: LABOUR-BASED STONE PAVED ROADS

Source: **S A1-Fayadh. Labour-based Stone Paved Roads. Kampang Cham Province International Labour Organisation. Technical Assistance to the Labour-based Rural Infrastructure Works Programme CMB/97/M02/S10**

Table F1: Work Norms: Labour-based stone paved roads

G: EARTHWORKS

Source: **McCutcheon, RT, van Zyl CWL, Croswell J, Meyer D and Watermeyer RB. Interim guidelines for Labour-based construction projects. Construction and Development series. Number 2 Development Bank of Southern Africa February 1993**.

Table G1: Average Task Output Values
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H: STORMWATER DRAINAGE

Source: **Balmaceda P, John R and Horak E. Planning and construction of a stormwater system by labour-intensive methods in an urban environment. Fifteenth Annual Transportation Convention, 1995**.

Table H1: Output data assumed for feasibility analysis
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J: BITUMEN SURFACING

Source: **SABITA Labour enhanced construction for bituminous surfacings Manual II March 1993**

Table J1: Preliminary South African bitumen surfacing production rates under average conditions

K: ROAD PROJECTS

Source: Greyling MR, Critical analysis of labour-intensive road projects in South Africa funded form the sale of strategic oil. A dissertation submitted to the faculty reservers of Engineering, University of the Witwatersrand, Johannesburg, in fulfillment of the requirements for the degree of Master of Science of Engineering, 1994.

Table K1: Productivity achieved per activity (Pa) for each road authority
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N: TASK OUTPUT RATES

Source: Department of Public Works: Guidelines for enhancing employment opportunities in the delivery of infrastructure projects – a national Public Works Programme Initiative

Table N1: Task output rates

O: TYPICAL TASK RATES

Source: McCutcheon and Marshall. Labour-intensive construction and maintenance of rival roads: Guidelines for the training of road builders. Construction and Development Series, November 14, Development bank of Southern Africa. Development Paper 60, November 1996.

Table O1: Average task output values
Table O2: Detailed task rates for excavation

APPENDIX 1: QUANTITATIVE EMPLOYMENT DATA ON SELECTED CONSTRUCTION ACTIVITIES

Comprehensive quantitative data on employment generated by various construction activities is generally lacking in the literature. The data which follows, however, appears in the literature. Users of this data should consult the publications referenced to obtain the assumptions behind the reported data.

A: HOUSING AND RELATED INFRASTRUCTURE

Source: Watermeyer and Band's National Housing Forum Report (1994) on the Development of Small Scale Enterprises, Skills, Entrepreneurship and Employment Opportunities through the Provision of Housing (see www.targetedprocurement.com)

Chapter 2: Employment opportunities through the provision of housing

Table A1 : Approximate number of manhours required to manufacture various building and construction materials

ITEM	DESCRIPTION	UNIT	MANHOURS PER UNIT	SOURCE OF INFORMATION	REMARKS
Aggregates	- sands for mortar, plaster and subbase material - sands for concrete - stone for concrete; aggregate for waterbound macadam; crushed stone for road base courses - transport	ton ton ton ton	0,12 0,15 0,27 0,13	Hippo Quarries (M Doyle)	20 km haul distance, 12 ton truck; one mechanic to 10 trucks
Asbestos		ton	41,5	Central Asbestos (Pty) Ltd (J Maree)	
Bitumen	road grade	ton	0,7	SABITA (R Vos)	Distribution to within 200km. Excludes imported crude oil.
Cement	OPC	ton	1,1	Anglo Alpha (C Ehrke)	Transport and distribution excluded
Clay sewer pipe	150 mm diam - raw material - manufacture TOTAL 100 mm diam pipe - raw material - manufacture TOTAL 150x150mm junction - raw material - manufacture TOTAL 100 mm 90 Bend - raw material - manufacture TOTAL	100 m 100 m No No	 1,90 66,30 68,20 1,03 45,04 46,07 0,01 0,86 0,87 0,01 0,30 0,31	Vitro Building Products (H Grobler)	Including constituent materials, but no distribution
Clay masonry units	106 x 212 x 73 - hightech plant - normal plant	No 1 000	 3 9 - 9,5	Clay Brick Association (N Louw)	Production manhours vary depending on plant used.
Concrete masonry units	140 mm (hollow) - materials - production	10 m^2	 0,6 5,1 - 7,6	Concrete Masonry Association (P Kelly)	Excludes transport to site. Production

	TOTAL 140 mm (solid) - materials - production TOTAL 140 mm (hollow) - materials - production TOTAL	 10 m^2 10 m^2	5,6 - 8,2 1,1 5,1 - 7,6 6,2 - 8,8 2,4 20,0 22,4	Portland Cement Institute (B Raath)	manhours vary depending on plant used. Manual equipment Own quarry Hand mixing
Concrete paving units	. 65 mm thick - materials - production TOTAL	10 m^2	 0,5 3,1 - 3,6 3,6 - 4,1	Concrete Masonry Association (P Kelly)	Excluding transport to site
Concrete pipes	Stormwater pipe 450 mm diam 600 mm diam - material - production TOTAL 900 mm diam - material - production TOTAL 1 350 mm diam - material - production TOTAL Sewer pipe 450 mm 600 mm 900 mm 1 350 mm	 100 m 100 m 100 m 100 m 100 m 100 m 100 m 100 m	 100 45 80 125 100 100 200 215 120 335 104 132 210 350	Fraser Fyfe (Pty) Ltd (A Dutton)	Including raw materials Including raw materials and sacrificial lining
Concrete roof tile	- production - materials TOTAL	10 m^2	0,66 0,22 0,88	Watson Tile Corporation (K Watson)	
Door frames	standard	No	0,5	Wispeco (N Crosby)	Excludes steel in frame
FC Roof sheeting	 - production - materials TOTAL	10 m^2	 3,9 0,2 4,1	Everite (P North)	
FC Ceiling board	4 mm - production - materials TOTAL	10 m^2	 1,8 0,1 1,9	Everite (P North)	
FC sewer pipe	150 mm diam	100 m	23	AC Pipes Klipriver (A Kapp)	Includes all constituent materials
Gate valve	80/90 mm diam RSV	No	2,0	Czechtech cc (R Garrett)	Includes casting, machining, assembly and overheads
Glass	3 mm float - production - materials TOTAL	100 m^2	 3,6 0,6 4,2	PFG Flat Glass (J Henning)	
Gypsum ceilings		10 m^2	3,25	Gypsum Industries (Snowden)	12,5 mm
HDPE pipe	600 mm spiral wound - material - production TOTAL 32 mm dia (water) - materials - manufacture TOTAL	100 m 100 m	 7 178 185 1 2 3	Spiropipe (A Rex) Main Industries (D Chesney-Jones)	 Class 12
Hyson-cells		100 m^2	0,03	Hyson-cells (J Brokenshire)	

Paint	PVA	100 litre	5	Plascon Group Services (R Johannsen)	Excludes raw materials
Polyethylene/ (Pipe grade)	 - raw material - production - quality control - stockpiling TOTAL	ton	 0,08 2,59 0,55 0,06 3,28	Safripol (J Kellerman)	
Polypropylene/ (Pipe grade)	- raw material - production - quality control - stockpiling TOTAL	ton	0,08 4,54 0,56 0,06 5,23	Safripol (J Kellerman)	
Precast Concrete Products	- raw materials - mixing process - casting of concrete - transport - administration - maintenance TOTAL	ton	0,54 0,14 4,02 1,77 0,66 0,75 7,82	Blitz Betonwerke (N Erasmus)	Average for product range
Steel roof sheeting	0,6 mm galvanised - mining of iron ore, dolomite, coal, etc - Steel making to profiled section TOTAL	ton	 1,1 20 21,1	Iscor (S Evans)	Includes mining, etc, but excludes production of zinc for galvanising
Steel sections	Commercial grade angles, channels and IPEs - mining of iron ore, dolomite and coal, etc - steel making to rolling into sections TOTAL	ton	 1,1 9,0 10,1	Iscor (S Evans)	Includes mining, etc.
Timber	Structural grade - planting/ thinning/ pruning - harvesting - transport of logs to sawmill subtotal - processing - preservative treatment - transport to merchants - handling by merchants subtotal TOTAL	1 m^3	 2,5 2,5 0,3 5,3 10,0 2,0 0,3 2,0 14,3 19,6	SALMA (P Bryant)	Planting to saw mill represents a 28 year period. Processing to handling by merchants represents a 6 week period.
uPVC sewer pipe	160 mm diam (sewer) - materials - manufacture - distribution TOTAL 90 mm diam (water) - materials - manufacture - distribution Total	100 m 100 m	 1 22 7 30 1 24 7 32	Main Industries (Pty) Ltd (D Chesney-Jones)	Heavy duty pipe Class 12
Window frames	- ND 54 - NC1 - NC2	No No No	1,25 0,8 0,9	Wispeco (N Crosby)	Excludes steel in frame.
Zinc		ton	25,4	Zinc Corporation of South Africa (Ltd) (M Buncombe)	

Table A2 : Comparison of engineering materials

MATERIAL	MANHOURS TO PRODUCE A CUBIC METRE	MANHOURS TO PRODUCE A TON	REMARKS
Concrete +	1,6	0,7	
High density polyethylene	3,1	3,3	Pipe grade quality
Masonry' (class II mortar)	5,0	2,3	
Polypropylene*	4,9	5,2	Pipe grade quality
Steel	78,8	10,1	Angles, channels and IPEs Structural
Timber	19,6	39,2	grade

\+ Mechanical batching and mixing included.
* Pipe extrusion excluded
' Laying of units and mixing of mortar excluded

Table A3 : Manufacture of precast concrete components

OPERATION	ACTIVITIES	MANHOURS/ TON
Raw materials	Cement : production; transport to yard; pump into silo Aggregates : quarry operations; loading; transport	0,54
Mixing process	Boomscraper; weigh process; water supply	0,14
Casting of concrete	Cleaning of moulds : brushing; cleaning; carrying to cleaning area; mixing of oil; applying of oil to moulds; move to casting yard. Mesh reinforcement : cutting, carrying; placing. Casting and finishing : transport moulds; casting; vibrating; smoothing off Curing : cover moulds with canvas; placing of wet steamer; firing of boilers; steaming; filling of water tank; stacking; Remoulding : loosen sides; strip mould; transport to stacking area; stacking; carry moulds to steaming area	4,02
Transport	Load on fork truck; drive to truck; load truck with labour; cover load with netting; transport to erection area/township; offload	1,77
Administration		0,66
Maintenance of moulds	Welding; repairing; straightening; inspecting	0,75
TOTAL		7,82

Table A4 : The use of bitumen in *plant-based* and *labour-based* surfacing options

TYPE OF CONSTRUCTION	DESCRIPTION	Manhours/ ton of bitumen
Plant-based	Hot-mix asphalt Chip and spray Slurry	0,8 2,4 - 4,3 2,4
Labour-based	Cape seal and chip and spray Coarse slurry Hot-mix asphalt	30 60 15 - 20

* Sum of manhours involved in manufacture of materials, transport of materials and placing of surfacing

Table A5 : Manhours associated with the manufacture of 150 mm diameter sewer pipes

PIPE MATERIAL	MANHOURS REQUIRED TO PRODUCE A METRE OF PIPE*	UNIT COST/MANHOUR (Rand/manhour)
Clay	0,68	R27-94
UPVC	0,23	R65-22
Fibre cement	0,23	R86-96

* No allowance for transport and distribution included.

Table A6 : Typical manhours required in the manufacture of building components

COMPONENT	UNIT	APPROXIMATE NUMBER OF MANHOURS REQUIRED TO MANUFACTURE A UNIT	REMARKS
Ceilings - 4 mm fibre cement	m5	0,3	Including timbers supports
- 6,4 mm gypsum	m5	0,3	
Concrete -	m5	1,2	Grade 15 or 20
Cladding - 12,7 mm gypsum	m5	0,35	Excludes timber supports
Doors - external	No	2,2	Standard door (timber) + frame
- internal	No	1,4	
Masonry - 90 mm walls	m5	0,45	
- 110 mm wall	m5	0,55	
- 140 mm walls	m5	0,7	
- 220 mm walls	m5	1,1	Negligible
Paint	m5	-	
Plaster - one coat (external)	m5	0,95	
- one coat (internal)	m5	0,9	
Roofing - concrete tiles	m5	0,2	Includes purlins/battens
- galvanised iron	m5	0,2	
- fibre cement*	m5	0,5	
Roof trusses[55]			6 m span assumed;
- concrete tiles	m5	0,3	Fabrication excluded
- fibre cement	m5	0,25	
- galvanised iron	m5	0,25	
Screeds	m5	1,2	Includes glass and frames
Windows	m5	1,0	

* Imported asbestos excluded.

Table A7 : Number of manhours required in the construction of various masonry houses

FLOOR AREA (m^2)	PHYSICAL FACTOR	STRUCTURE AND FINISHES	NUMBER OF MANHOURS (hours)		
			MATERIALS*	SITE LABOUR+	TOTAL
45	38,6	• No water and sanitary fittings. • No electricity. • Double pitched, sheeted roof. • Ceilings • Bagged and painted internally and externally.	120	1 120	1 240
51	56,5	• Internal water and sanitary fittings. • Internal electrical reticulation. • Double pitched sheeted roof. • Ceilings • Plastered and painted internally and externally.	160	1 400	1 560
80	82,3	• Internal water and sanitary fittings. • Internal electrical reticulation. • Double pitched sheet roof. • Ceilings • Plastered and painted internally and externally.	200	1 700	1 900

\+ Estimated from Figure 2.1

* Estimate for basic structure and finishes based on house plans and Table 2.11; manhours involved in sanitary services, electrical services and sundry items such as carpentry are not included.

Table A8: Kwa Thema Extension 7 : civil services for 805 erven constructed using conventional *plant based* methods

SERVICE	LEVEL OF SERVICE	UNITS/ ERF	COST/ ERF	ESTIMATED NUMBER OF MANHOURS (manhours/erf)		
				MATERIALS	CONSTRUCTION +	TOTAL
Water	• Class 9 uPVC pipes (63 mm to 200 mm diam.) • Resilient seal gate valves and fire hydrants • Erf connections and water meters in boxes	10,0 m	789	5	34	39
Sewer	• 100 mm diam clay sewer pipes. • Manholes and erf connection	8,4 m	618	7	36	43
Stormwater	• 450 - 750 mm diam concrete pipes Junction boxes, manholes and catchpits • Headwalls and stone pitching • Concrete stormwater channels across roads • Earth drains	0,9 m	403	2	24	26
Roads	• Cast insitu kerbing • Cable ducts • 25% asphalt, surfaced roads on crushed stone bases; remainder provided with a gravel wearing course	47 m^2	755	3	18	21
TOTAL	All services		2565	17	112	129

* Including P & G but excluding VAT and professional fees (March 1992)
\+ Construction labour including non-productive P & G time (Average between two construction companies)
' Estimate based on Table 2.7

Table A9 Manhours required in the provision of *infrastructure* for a low cost township using conventional construction methods+

SERVICE	ESTIMATED MANHOURS (%)		ESTIMATED TOTAL NUMBER OF MANHOURS/ERF	COST/MANHOUR (Rand/manhour)
	MATERIALS	SITE LABOUR		
Water	13	87	39	20
Sewerage	16	84	43	14
Roads	14	86	21	36
Stormwater	8	92	26	16
Electricity	70	30	117	20

\+ Based on Tables 2.14 and 2.15

Table A10 : <u>Comparison of the number of manhours required to construct non-masonry and masonry houses</u>

CONSTRUCTION TYPE	NUMBER OF MANHOURS (hours)			NUMBER OF MANHOURS FOR EQUIVALENT MASONRY HOUSES (hours)*		
	MATERIALS+	SITE LABOUR	TOTAL	MATERIALS+'	SITE LABOUR	TOTAL
Timber (SALMA)[12]	300	1 180	1 480	200	1 700	1 900
Precast concrete panels and posts (Blitz)[11]	150	210	360	120	1 120	1 240
Steel frame with 110 mm brick infill panels (Belaton)[56]	330	880	1 210	160	1 400	1 560

\+ Based on information received by manufacturers and estimates from Table 2.12; manhours involved in sanitary services, electrical services and sundry items not included.
* See Table 2.13.
' *Plant-based* masonry manufacture.

Table A11 : Kwa Thema Extension 7 : water and sewer reticulation for 805 erven using *labour-based* methods of construction

SERVICE	LABOUR MANHOURS/ERF*		COST/MANHOUR+ Rand/manhour)	
	Plant-based	*Labour-based*	*Plant-based*	*Labour-based*
Water Sewerage	39 43	58 72	20 14	14 9

* Includes manhours in respect of P & G and manufacture of materials.
\+ Based on assumption that *plant-based* and *labour-based* technologies have no effect on cost.

Table A12 : Manhours required to provide and construct various township roads

ROAD	CONSTRUCTION TECHNOLOGY	WIDTH (m)	Man-hours/m^{2+}	Man-hours/km +	*Labour-based* to *plant-based* ratio
Manhours for gravel roads					
Class D: light gravel	*Plant-based* *Labour-based*	5 5	0,24 1,86	1 215 9 300	7,7
Class D: heavier gravel	*Plant-based* *Labour-based*	5 5	0,50 3,67	2 475 18 350	7,4
Manhours for 3 m wide surfaced Class D roads					
Slurry with gravel base	*Plant-based* *Labour-based*	3 3	1,48 8,06	4 431 24 183	5,5
Slurry with WBM base	*Plant-based* *Labour-based*	3 3	2,27 7,75	6 819 23 253	3,4
Asphalt with G3 base	*Plant-based* *Labour-based*	3 3	1,50 6,39	4 500 19 155	4,3
Asphalt with WBM base	*Plant-based* *Labour-based*	3 3	2,30 6,96	6 909 20 880	4,6
Concrete block	*Plant-based* *Labour-based*	3 3	2,19 6,82	6 555 20 460	3,1
Manhours for 5 m wide surfaced Class D roads					
Slurry with gravel base	*Plant-based* *Labour-based*	5 5	1,18 7,54	5 885 37 705	6,4
Slurry with WBM base	*Plant-based* *Labour-based*	5 5	1,95 7,13	9 765 35 655	3,7
Asphalt with G3 base	*Plant-based* *Labour-based*	5 5	1,19 5,72	5 950 28 575	4,8
Asphalt with WBM base	*Plant-based* *Labour-based*	5 5	1,99 6,33	9 965 31 650	3,2
Concrete block	*Plant-based* *Labour-based*	5 5	1,77 6,02	8 825 30 100	3,4
Manhours for 6 m wide surfaced Class B roads					
Slurry with gravel base	*Plant-based* *Labour-based*	6 6	1,13 6,61	6 750 39 636	5,8
Slurry with WBM base	*Plant-based* *Labour-based*	6 6	2,05 7,62	12 270 45 726	3,7
Asphalt with G3 base	*Plant-based* *Labour-based*	6 6	1,20 6,08	7 170 36 450	5,1
Asphalt with WBM base	*Plant-based* *Labour-based*	6 6	2,12 7,09	12 690 42 540	3,3
Concrete block	*Plant-based* *Labour-based*	6 6	2,01 8,19	12 072 49 140	4,1

\+ Estimates based on assumptions set out in Appendix 2A.

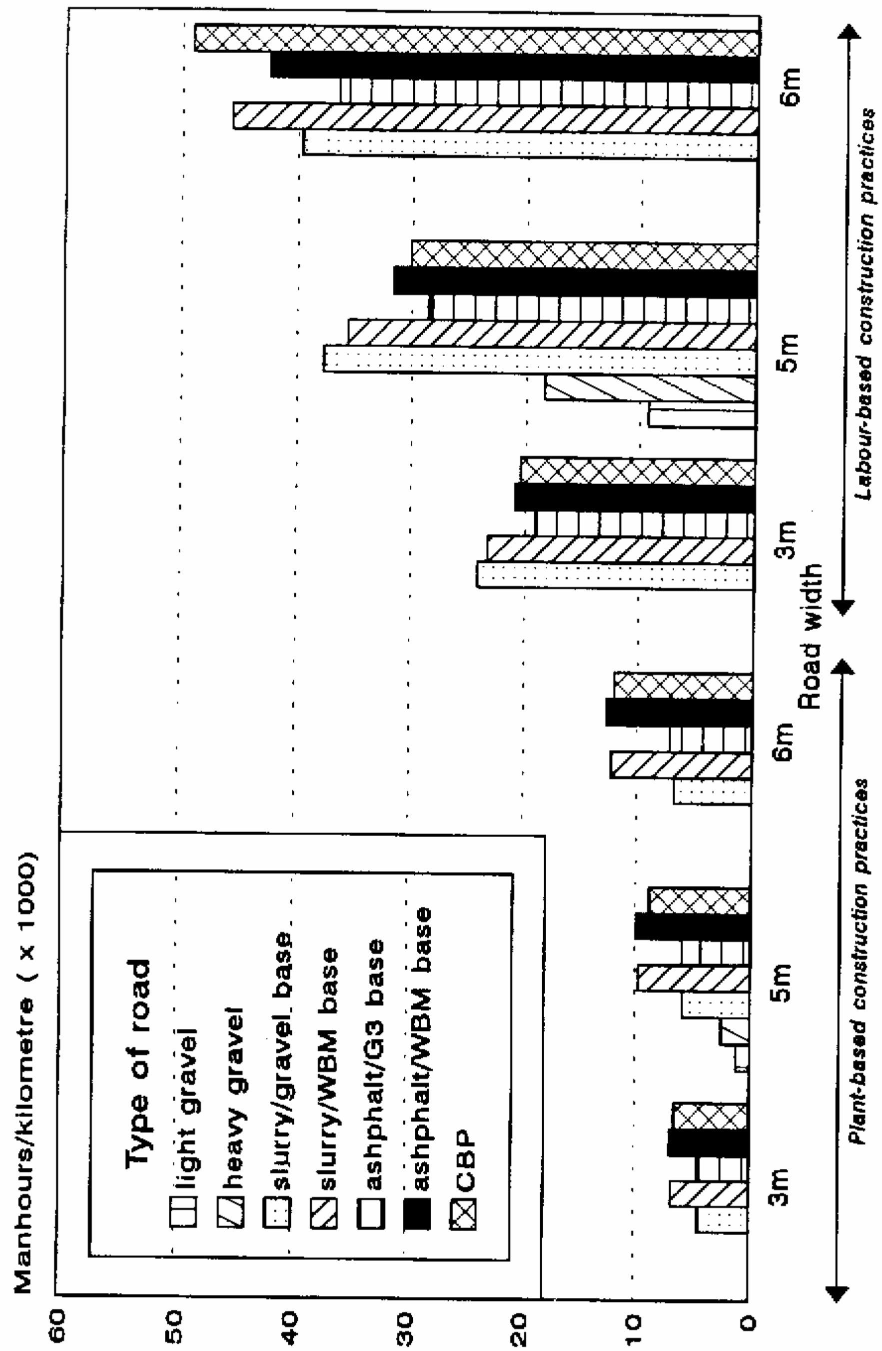

Figure 2.2: Number of manhours required to construct a kilometre of road

Table A13: Manhours associated with roadwork layers

LAYER	THICKNESS	MANHOURS TO PRODUCE AND CONSTRUCT (manhours/m²)	
		PLANT-BASED [39]	*LABOUR-BASED*
Road bed preparation(R & R)		0,033	0,350
Gravel wearing course(G5)	125	0,160	1,000
Gravel wearing course(G4)	150	0,192	1,200
Base course (G4)	150	0,192	1,200
Base course (G3)	125	0,165	-
Subbase (G6)	150	0,192	1,200
Waterbound Macadam base course)	100	1,040	1,370

Table A14 : Manhours required to surface roads

SURFACING		MANHOURS IN RESPECT OF MATERIALS AND CONSTRUCTION (manhours/m²)	
TYPE	THICKNESS (mm)	*PLANT-BASED*	*LABOUR-BASED*
Slurry	15 mm	0,110	2,011
Asphalt	25 mm	0,140	1,170
Concrete blocks	60 mm	0,930 +	2,120'

\+ Factory produced block paving
' Blocks manufactured on site using labour-intensive equipment

Table A15: Manhours required to provide and construct an in-situ paved block pavement[41]

OPERATION	MANHOURS/m²			
	OPTION NUMBER			
	1	2	3	4
	Concrete pump mixer and front end loader	*Concrete pump mixer and wheel barrows to place grout*	*Hippo drums and wheel barrows*	with crushing own stone and sieving sand
Laying of cells.	0,06	0,06	0,06	0,06
Place stones and compact.	0,10	0,37	0,37	0,99
Mix and place grout.	0,10	0,19	0,37	0,72
Finishing.			0,03	
	0,03	0,03		0,03
TOTAL	0,38	0,65	0,83	1,80

* Sum of manhours involved in manufacture of materials, transport of materials and construction of surfacing. Preparation of insitu soil not included. Manhours in respect of materials based on information contained in Table 2.7.

Chapter 4: RECENT DEVELOPMENTS IN EMPLOYMENT OPPORTUNITIES IN THE PROVISION OF *INFRASTRUCTURE*

Table A16 : Productivities for piece and task work in KwaZulu

ACTIVITY	RATE	
	LAST 500 m SECTION B (PIECEWORK)	REMAINDER OF PROJECT (TASK WORK)
Clearing (Medium to thick bush)	34 m□/person/day	20 to 45 m□/person/day
Setting out (bulk earthworks & surfacing) - team size (4 + 1)	125 /day	100 m/day
Bulk earthworks (including spreading and levelling)	3,3 m□/person/day	0,8 to 1,8 m/person/day
Excavation of stormwater drains (Average depth 1m, 350 mm width)	1,5 m□/person day	0,9 to 2 m□/person/day
Drifts (unlined) - team size (5 + 1)	1 drift/day for 5 man team	□ drift/day for 5 man team
Surfacing	5,5 m/person/day	5 m/person/day

Table A17 : Trends in excavation rates for pickable material in various projects [6]

Project/Programme	Production rates for excavation in pickable material
Soweto's Contractor development Programme[6]	2,8 to 3,2 m³/6 hour task
Kenyan Rural Roads Programme[2]	3,0 m³/man day
Kwa Zulu road construction[80]	0,7 to 1,0 m³/man day
Kwa Zulu road construction[12]	0,3 to 1,1 m³/man day
Gazankulu and Venda[81]	1,0 m³/person day
Ciskei[82]	0,6 to 0,8 m³/man day
Ilinge[27]	2,3 m³/man day
Ibhayi[34]	6,0 m³/man/day
Siviele Konstruksie[41]	5 - 12 m³/man day
SAFCEC[21] - up to 1,0 m deep	2,5 - 5,0 m³/man day
- up to 1,5 m deep	1,1 - 4,0 m³/man day
World Bank standard[85]	3,0 to 4,0 m³/man day

Typical production rates, based on the authors' experience, for a 6 hour task, in soft materials where the depth of excavation does not exceed 2,5 m, are presented in Table 4.5.[79] It can be seen from Table 4.5 that productivity drops sharply as the material becomes more difficult to excavate by hand, the approximate ratios between soft class 1 : soft class 2 : soft class 3 being approximately 2,1:1,6:1,0 and for depths of 0-1,0:1,0-1,5:1,5-2,0:2,0-2,5 being approximately 2,2:1,9:1,5:1,0. Alternative excavation rates for different types of material, including hard rock, are presented in Table 4.6. It should be noted that productivities can vary between communities, for the same ground conditions. This may be attributed to different work ethics being prevalent. Thus although the figures contained in Table 4.5 may be regarded as being typical, they do not necessarily apply in all communities.

Table A18: Trench excavation rates for a 6 hour task[79]

EXCAVATION TYPE*	TYPICAL PRODUCTION PER 6 HOUR TASK FOR DEPTH RANGE (m³)			
	0 - 1,0	1,0 - 1,5	1,5 - 2,0	2,0 - 2,5
soft class 1	3,5	3,0	2,4	1,6
soft class 2	2,8	2,4	1,9	1,3
soft class 3	1,7	1,5	1,2	0,8

* Refer to Appendix B for classification of material types.

Productivity is also affected by the level of skill. This is clearly evident in certain of the production rates presented in Table 4.6. A document prepared for the South African Roads Board makes the observation that *improved productivity can be expected once skills have been extensively developed. The people involved will realise that they can improve their income by producing more of the finished or required product. This will develop a healthy competition for the available work.*[40]

APPENDIX A : STUDY ON LABOUR COMPONENT OF ROADS

Basis for calculation

Estimates of the number of manhours/m² of road constructed are based on the sum of the following, as appropriate :

- labour required to produce raw materials such as cement in a cement plant.
- labour required to manufacture precast concrete products either in a factory or on site.
- labour required to obtain materials in quarrying operations.
- labour to transport materials or precast concrete products to the site.
- labour to construct layers and items.

Assumptions

The following assumptions were made :

- plant productivity is equal to SAFCEC norms.

* *labour-based* tasks are based on an 8 hour day and *plant-based* tasks on a 9,5 hour day.
* all gravel materials are available at a 20 km haul distance.
* crushed stone is available at a 20 km haul distance.
* all plant and equipment are freely available on the site in question.
* roadway has single camber
* ground surface has a fall parallel to the camber.
* depth of final road surface is 120 mm below original ground level.
* box cut extends 300 mm beyond kerb.
* all material from box cut is spoilt.
* double handling is required with respect to excavated material as spoil is stockpiled prior to spoiling in *labour-based* approach.
* hand quarrying and hand loading assumed in *labour-based* approach.
* all excavated material is classified as soft class 2.

Table A19 : Manhours associated with layerworks and kerbing on various township roads[44]

LAYER	**TYPE**	**MANHOURS REQUIRED TO CONSTRUCT A SQUARE METRE OF ROAD**	
		Plant-based	*Labour-based*
Light gravel road, 5 m wide			
Wearing course	125 G5	0,160	1,000
Box cut to spoil		0,050	0,510
R&R subgrade		0,033	0,350
Kerbing	nil	-	-
TOTAL		0,243	1,860
Heavier gravel road, 5 m wide			
Wearing course	150 G4	0,192	1,200
Subbase	125 G5	0,160	1,000
Box cut to spoil		0,110	1,120
R&R subgrade		0,033	0,350
Kerbing	nil	-	-
TOTAL		0,495	3,670
Class D road, 3 metre wide, with bituminous slurry surfacing			
Surfacing	Slurry 15 mm	0,110	2.011
Basecourse	150 G4	0,192	1,200
Subbase	150 G6	0,192	1,200
Box cut to spoil		0,220	1,320
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,730	0,980
TOTAL		1,477	8,061
Class D road, 3 metre wide, slurry surfacing, WBM			
Surfacing	Slurry 15 mm	0,110	2,011
Basecourse	100 WBM	1,040	1,370
Subbase	125 G6	0,160	1,000
Box cut to spoil		0,200	2,040
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,730	0,980
TOTAL		2,273	7,751
Class D road, 3 metre wide, with asphalt surfacing			
Surfacing	Asphalt 25 mm	0,140	1,170
Basecourse	125 G3	0,165	0,165
Subbase	150 G6	0,192	1,200
Box cut to spoil		0,240	2,520
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,730	0,980
TOTAL		1,500	6,385
Class D road, 3 metre wide, asphalt, WBM			
Surfacing	Asphalt 25 mm	0,140	1,170
Basecourse	100 WBM	1,040	1,370
Subbase	125 G6	0,160	1,000
Box cut to spoil		0,200	2,090
R&R subgrade	Mountable	0,033	0,350
Kerbing		0,730	0,980
TOTAL		2,303	6,960

Class D road, 3 metre wide, concrete block surfacing			
Surfacing	Concrete block	1,040	2,310
Basecourse	150 G4	0,192	1,200
Box cut to spoil		0,190	1,980
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,730	0,980
TOTAL		2,185	6,820
Class D road, 5 metre wide, with bituminous slurry surfacing			
Surfacing	Slurry 15 mm	0,110	2,011
Basecourse	150 G4	0,192	1,200
Subbase	150 G6	0,192	1,200
Box cut to spoil		0,210	2,190
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,440	0,590
TOTAL		1,177	7,541
Class D road, 5 metre wide, slurry surfacing, WBM			
Surfacing	Slurry 15 mm	0,110	2,011
Basecourse	100 WBM	1,040	1,370
Subbase	125 G6	0,160	1,000
Box cut to spoil		0,170	1,810
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,440	0,590
TOTAL		1,953	7,131
Class D road, 5 metre wide, with asphalt surfacing			
Surfacing	Asphalt 25 mm	0,140	1,170
Basecourse	125 G3	0,165	0,165
Subbase	150 G6	0,192	1,200
Box cut to spoil		0,220	2,240
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,440	0,590
TOTAL		1,190	5,715
Class D road, 5 metre wide, asphalt, WBM			
Surfacing	Asphalt 25 mm	0,140	1,170
Basecourse	100 WBM	1,040	1,370
Subbase	125 G6	0,160	1,000
Box cut to spoil		0,180	1,850
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,440	0,590
TOTAL		1,993	6,330
Class D road, 5 metre wide, concrete block surfacing			
Surfacing	Concrete block	0,930	2,120
Basecourse	150 G4	0,192	1,200
Box cut to spoil		0,170	1,760
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,440	0,590
TOTAL		1,765	6,020
Class B road, 6 metre wide, with bituminous slurry surfacing			
Surfacing	Slurry 15 mm	0,110	2,011
Basecourse	125 G3	0,165	0,165
Subbase	150 C4	0,267	1,600
Box cut to spoil		0,190	1,990
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,360	0,490
TOTAL		1,125	6,606
Class B road, 6 metre wide, slurry surfacing, WBM			
Surfacing	Slurry 15 mm	0,110	2,011
Basecourse	125 WBM	1,160	1,580
Subbase	150 G5	0,192	1,200
Box cut to spoil		0,190	1,990
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,360	0,490
TOTAL		2,045	7,621
Class B road, 6 metre wide, with asphalt surfacing			
Surfacing	Asphalt 30 mm	0,170	1,400
Basecourse	125 G3	0,165	0,165
Subbase	150 C4	0,267	1,600
Box cut to spoil		0,200	2,070
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,360	0,490
TOTAL		1,195	6,075

Class B road, 6 metre wide, asphalt, WBM			
Surfacing	Asphalt 30 mm	0,170	1,400
Basecourse	125 WBM	1,160	1,580
Subbase	150 G5	0,192	1,200
Box cut to spoil		0,200	2,070
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,360	0,490
TOTAL		2,115	7,090
Class B road, 6 metre wide, concrete block surfacing			
Surfacing	Concrete block	0,930	2,120
Basecourse		0,267	1,600
Subbase	150 C3	0,192	1,200
Box cut to spoil	150 G5	0,230	2,430
R&R subgrade		0,033	0,350
Kerbing	Mountable	0,360	0,490
TOTAL		2,012	8,190

B: MINIMUM PRODUCTIVITY LEVELS

Source: **Notice in terms of Section 70(2) of the Labour Act, 1992. Agreement on conditions of employment entered into between the Metal and Allied Namibian Works Union and the Construction Industries Federation of Namibia 6 April 2000, Government Gazette 31 May 2000 (No. 2340).**

The minimum wage rate as determined and agreed under item 3 above are subject to minimum productivity levels as below. Failure to maintain productivity levels will be addressed by additional training or disciplinary and incapacity procedures as the case may be.

1. Labourer

Excavations in pickable material (not exceeding 2m deep)	2 to 7m³ / day
Filling under surface beds	5 to 7m³ / day
Concrete (mix and place in terms of 1 artisan / 10 labourers)	3 to 6m³ / day

2. Bricklayer / Plasterer

Stock bricks	685 no. / day
Face bricks	450 no. / day
Plaster to horizontal surfaces	22,5m² / day
Plaster to vertical surfaces	31,5m² / day

3. Carpenter

Rough formwork to all structures	22,5m² / day
Smooth formwork to all structures	16,2m² / day
Hanging doors with furniture	8 no. / day
Ceilings including brandering	27m² / day
Roof covering including purlins	67,5m² / day

4. Tiler

Glazed tiles to walls	19,8m² / day
Ceramic tiles to floors	21,6m² / day

5. Painter/Glazier

Undercoat and two coats paint to walls	37,8m² / day
Undercoat and two coats paint to ceilings	30,6m² / day
Two coats varnish to wood	32,4m² / day
Prime, first coat and two coats enamel to surfaces	32,4m² / day
Glazing generally	31,5m²/day

6. VA Tile / Carpet Layer

VA tiles to floor	72m² / day
Carpet plus underfelt to floors	67,5m² / day

C: ESTIMATED PRODUCTION RATES FOR CONCRETE BLOCK PAVING

Source: **A Nkambule: A review of Labour Intensive Concrete Block Paving van Wyk and Louw Inc.**

Table C1: Labour Intensive Production rates

Operation	Activity	Minimum task
Site clearance	Bush clearing Stripping and grubbing Tree and stump removal	(R McCutcheon) 150 – 750 m²/day 100 – 200 m²/day Experience
Earth works	Slotting Excavation to level: Cut < 250 mm > 250 mm Borrow to fill: Excavate & load (throwing 0-4m) in:- loose soil firm soil hard soil Haulage (wheelbarrow): 0-20m 40-60m 80-100m Spreading	4m³/day (R McCutcheon) 5 m³/day 4 m³/day 3.5m³/day (K25-Work study) 2.5m³/day 1.5m³/day 13.5m³/day (R McCutcheon) 8.0m³/day 5.5m³/day 12m³/day
Edge restraint	Lay precast kerb units Backfill to side wall and hand tamping Concrete edge beam	10m/day (C. Dyer) 3m³/day 10m/day (Montshioa Report)
Block paving	Placing the bedding sand, laying the units, compacting the units, filling the joints and removing excess sand.	16m²/day (SA Const World Oct 1994) 100m²/5 persons/day (Montshioa Report)

D: CONCRETE MASONRY GRAVITY DAMS CONSTRUCTION

Source: **King CD. Employment creation through the design and construction of medium sized concrete masonry gravity dams in South Africa using Labour-based construction methods: A comparison of alternative technologies. A project report submitted to the faculty of engineering, university of the Witwatersrand, Johannesburg in partial Fulfillment of the requirements for the degree of Master of Science in engineering Johannesburg, 1994.**

Table D1: BALFOUR DAM: PRODUCTIVITY FIGURES FOR REQUIRED CONSTRUCTION ACTIVITIES

Activity	Date	Output
Stone collecting	1991	0,09m³/man/day
	September 1994	0,57m³/man/day
Concrete building	September/October 1993	0,71m³/man/day
	October/November 1993	0,61m³/man/day
	November/January 1994	0,43m³/man/day
	January/February 1994	0,74m³/man/day
	September 1994	2,29m³/man/day
Block making	September/October 1993	3,14 blocks/man/day
	October/November 1993	2,2 blocks/man/day
	November/January 1994	2.14 blocks/man/day
	January/February 1994	2,83 blocks/man/day
	September 1994	4,56 block/man/day

NOTE:

(i) Items like stone collecting is not on-going everyday. The team is used for excavating and cleaning as well, so accurate figures are not obtainable.

(ii) Stones are added to the concrete when it is cast in the wall. These two operations can only match the volumes of concrete batched and the teams cannot thus control their own productivity.

E: **EXCAVATION**

Source: **A critical analysis of the community-based Public Works Programme in South Africa. A discertation submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in fulfillment of the requirements for the degree of Master of Science in Engineering, Johannesburg, July 1996**

Table E1: **Productivity data for excavation by hand**

Material Type	**Excavation only cu.m/man-day**		
	Daily paid	Task work	Piece work
Soft/very loose soil	1.67-5.00	3.34-10.00	6.67-20.00
Firm/loose soil	1.04-3.13	2.09-6.26	4.17-12.50
Stiff/compact soil	0.75-2.25	1.50-4.50	3.00-9.00
Very stiff/dense soil	0.60-1.79	1.19-3.57	2.38-7.14
Hard/very dense soil	0.49-1.47	0.98-2.94	1.96-5.88
Soft rock	0.42-1.25	0.84-2.51	1.67-5.01

Source: Derived Table from World Bank (in Coukis, 1983:180 & 284)

F: **LABOUR-BASED STONE PAVED ROADS**

Source: **S A1-Fayadh. Labour-based Stone Paved Roads. Kampang Cham Province International Labour Organisation. Technical Assistance to the Labour-based Rural Infrastructure Works Programme CMB/97/M02/S10**

Table F1: **Work Norms: Labour-based stone paved roads**

Task	Method	Unit	Work Norm Unit/day	Remarks
Breaking stone boulders	Crowbar and sledgehammer	Blocks	17 20	200mm thick blocks 150mm thick blocks
Loading and unloading blocks from trucks or oxcarts	Wheelbarrow and/or by hand	Blocks	180	Unskilled labour
Shaping the blocks	Club hammer and cutting tools	Blocks	100	Unskilled labour
Dressing the blocks	Club hammer and cutting tools	Blocks	50	Unskilled labour
Box cutting, sand cushioning and construction filter drains	How, shovel, spade, rake / spreader, pickaxe, mattock, bungee or basket, wheelbarrow, hand rammer and watering can	m^3	1.75	Unskilled labour
Packing stones	Club hammer and by hand	m^2	6.50	Skilled labour
Filling voids	Shovel, spade, rake / spreader, bungee or basket and wheelbarrow	m^2	30	Unskilled labour
Compaction	Plate compactor and pedestrian roller	m^2	30	Unskilled labour
Construction of shoulder	Hoe, shovel, spade, rake / sp reader, pickaxe, mattock, bungee or basket, wheelbarrow, hand rammer and watering can	m^2	20	Unskilled labour
Clearing the site		m	20	Unskilled labour

G: EARTHWORKS

Source: McCutcheon, RT, van Zyl CWL, Croswell J, Meyer D and Watermeyer RB. Interim guidelines for Labour-based construction projects. Construction and Development series. Number 2 Development Bank of Southern Africa February 1993.

Table G1: Average Task Output Values

Operation	Activity	Minimum Task
Site clearance	Bush clearing - dense - light to medium Stripping and grubbing Tree and stump removal Boulder removal	Determine on site 150m² – 750m²/day 100m² - 200m²/day experience 200 day/km
Earthworks	Slotting Excavation to level Cut < 0,25m > 0,25m borrow to fill Haulage (wheelbarrow) 0-20m 40-60m 80-100m Spreading	4m³/day 5m³/day 4m³/day 4m³/day 13,5m³/day 8,0m³/day 5,5m³/day 12m³/day
Drainage	Ditching Sloping Camber formation Mitre drains Catchwater drains Scour checks Culvert installation	3,75m³/day 3,75m³/day 100m²/day 3,75m³/day 3,75m³/day 25/day max. 20 days/line
Gravelling	Excavation Load Spreading	3m³/day 6m³ (loose)/day 12m³/day

Source: McCutcheon (1983) an Simpson (1980)

Table G2: Detailed task rates for excavation

Soil type	Tools	Task Rates (m³/man-day)		
		Throwing Distance (m)		
		0-4	4-6	6-8
Loose, not sticky soil	Shovel, jembe	5,0-6,0	4,5-5,5	3,5-4,5
Firm soil	Shovel, fork jembe	3,5-4,5	3,0-4,0	2,5-3,5
Very hard soil, hard soil mixed with stones	Pickaxe, fork jembe, shovel	2,0-3,0	1,8-2,5	1,7-2,5

Source: de Veen (1980)

H: STORMWATER DRAINAGE

Source: **Balmaceda P, John R and Horak E. Planning and construction of a stormwater system by labour-intensive methods in an urban environment. Fifteenth Annual Transportation Convention, 1995.**

Table: H1: Output data assumed for feasibility analysis

MAIN ACTIVITY	SUBACTIVITY	GANG SIZE	PRODUCTION RATE
Machine Excavation	Excavation of soft soil	Only supervisor	100 m³
	Excavation of soft rock	Only supervisor	30 m³
	Excavation of hard rock	Only supervisor	6 m³
Hand Excavation	Excavation of soft soil,10 man-gang	10-man gang	20 m³
	Excavation of soft rock, 10 man-gang	10-man gang	10 m³
Pipe laying by machine	Concrete pipes (ø 450mm): trimming, bedding, laying, backfilling & compaction	5-man gang	14,4 m
	Concrete pipes (ø 600mm): trimming, bedding, laying, backfilling & compaction	5-man gang	14,4 m
Pipe laying by hand	Concrete pipes (ø 450 mm): trimming, bedding, laying, backfilling & compaction	10-man gang	12 m
	Concrete pipes (ø 600 mm): trimming, bedding, laying, backfilling & compaction	10-man gang	9,6 m
	Plastic pipes (ø 450 mm): trimming, bedding, laying, backfilling & compaction	5-man gang	18 m
Masonry	Batching, mixing and pouring concrete for channel floor	5-man gang	3 m³
	Construction of brick-wall for culvert (transport, batching and mixing concrete)	10-man gang	60 m²
	Construction of kerb-inlets, manholes and grids (max length of chamber: 2,4m) (Transport, batching and mixing of mortar, machine backfilling & compaction)	5-man gang	0,33 number
	Construction of kerb-inlets, manholes and grids (max length of chamber: 2,4m) (Transport, batching and mixing of mortar, hand backfilling & compaction)	5-man gang	0,25 number

Table H2: Laying concrete pipes – summary of information from work study

PIPE DIAMETER	COSTING INFO	GANG UTILIZATION		INPUT/OUTPUT COEFF		OPTIMUM GANG SIZE
(mm)	(Man-hours/m)	Idle time %	Utilization %	(min/pipe)	(m/hour)	(number)
450	1,16	49,4	50,6	27,782	5,2	6
525	1,16	49,4	50,6	27,782	5,2	6
600	1,16	49,4	50,6	27,782	5,2	6
675	1,54	55,2	44,8	27,782	5,2	8
750	1,54	55,2	44,8	27,782	5,2	8

J: BITUMEN SURFACING

Source: SABITA Labour enhanced construction for bituminous surfacings Manual II March 1993

Table J1: Preliminary South African bitumen surfacing production rates under average conditions

ITEM	METHOD	PRODUCTION RATE
Sweep basecourse	Hand broom	1 000m²/man-day
Load and spray water and prime	Tractor, trailer, 2 000 litre tank, pump, spraybar	6 100m²/5 man-days
	Bakkie, 750 litre tank, handlances	3 800m²/5 man-days
	200 litre drum on trolley	3 300m²/5 man-days
Load, heat, spray dust palliative or bitumen onto geotextile	Tractor, trailer, 2 000 litre tank, pump, spraybar	2 800²/5 man-days
	Bakkie, 750 litre tank, handlances	1 800m²/5 man-days
	200 litre drum on trolley	1 500m²/5 man-days
Spread chip and backchip as required	Stone or sand	200-400m²/man-day
Slurry mix on site and spread	Small concrete mixer, hand tools	10m³/15 man-days

K: ROAD PROJECTS

Source: **Greyling MR, Critical analysis of labour-intensive road projects in South Africa funded form the sale of strategic oil. A dissertation submitted to the faculty reservers of Engineering, University of the Witwatersrand, Johannesburg, in fulfillment of the requirements for the degree of Master of Science of Engineering, 1994.**

Table K1: Productivity achieved per activity (Pa) for each road authority

ACTIVITY	UNIT (1)	KWZ	QWA	LEB	KWD	GAZ & VEN (2)	BOP	CIS	TRN-QMC	TRN-DWE	TRN-DAF
Site clearance											
(grubbing)	m^2/md	20-45	15-30	-	-	9	15-95	64-210	-	-	25
Excavation - loose	m^3/md	3	1.5-2.5	0.8	-	1	1.2-1.9	0.4-0.8	1.3	2.0	1.3
- stiff	m^3/md	-	1-2	0.6	0.3-0.5	-	0.5-0.8	-	0.8	-	0.8
Loading (1m rise)	m^3/md	6	6	-	-	-	1.4-1.9	15	-	2.0	2.0
Unloading	m^3/md	6	7	-	-	-	1.4-2.2	3	-	-	-
(300mm)											
Spreading/shaping	m^2/mcd	12	2.5	-	93	2.5	6	1.7	1-2	2	2.5-3
Watering: cart	m^2/md		25	-	-	-	12-64	-	-	-	-
: cans	m^3/mcd		-	-	35	-	-	14.7	-	-	-
Compaction	m^3/md										
vibratory											
-roller			12	-	-	-	17-53	-	-	52	20
-tamper			-	-		-	-	1.5	-	-	-
Grouted stone	m^3/md		0.6	-	2.5	-	-	-	-	0.2	-
pitching	m^3//md	1	-	0.4	-	1	-	3-6	-	0.6	-
Loose stone	m/md	0.5	0.8	0.4	0.4	1.5	-	-	-	1	-
packing	m/md		-	-	-	-	50	3.5	-	-	-
Pipe laying	m^3//md	0.5	1	0.4	-	-	-	0.5	-	-	-
Fencing	m^3//md		0.6-1.5	1.5-	-	-	-	0.75	1	0.3	-
Rock Collection	no./md	0.2	0.6	2	0.02	0.2	0.03	-	0.8-	0.6	-
(1km)											
Masonry walls	m^3//md		1.5	-	2	0.4	-	-	1.5	0.6	-
Drifts (dry	m/md	125	-	1.5	-	-	48	-	-	-	-
masonry)	m^3//md										
Concrete mix &	m^3//mcd		0.45	-	-	-	-	1-2	-	-	-
pour											
Setting out	m^3//mcd		-	0.4-	-	-	10-19	2	-	-	-
Gabion				0.6					-		
construction					57	-	-	15		-	-
Haul -	m^3//md								37	-	-
tractor/trailer											
- truck 3km			-	-	-	-	-				
-w/barrow (100m)			2	-				1	-		

NOTE:
1) md = man-days; mcd – machine-days
2) measurement and control of productivity only carried out on a limited basis
3) TPA, PAO,NPA CPA and KaNgwane have been excluded due to either the plant – intensive nature of their projects or lack of sufficient representative data.

Table K2: Productivity data for standard conditions

ACTIVITY	UNIT	PRODUCTIVITY NORM (Pn)	SOURCE
Site clearance (grubbing)	m²/md	100	ILO (CTP 40)
Excavation - loose	m³/md	5.1 (ave)	WB, Tab F-3
- stiff	m³/md	2.7 (ave)	WB, Tab F-3
Loading (1m rise)	m³/md	3.8	WB, Tab F-4
Unloading (300mm)	m³/md	6	WB, Tab F-4
Spreading / shaping	m³/md	11	WB, Tab F-7
Watering: cart (4000L)	m²/mcd	886	Appendix N
: cans (20L)	m²/md	37	Appendix N
Compaction - s roller (200kg)	m³/mcd	8 (150-200mm layer)	WB, Tab F-8
- tamper (75mm)	m³/md	3.8 (75mm, 3 passes)	WB, Tab F-9
Grouted stone pitching	m³/md	0.5	ILO (CTP 40)
Loose stone packing	m³/md	1.5	ILO (CTP 40)
Pipe laying	m/md	0.5	ILO (CTP 40)
Rock Collection (1km)	m³/md	2.5	ILO (CTP 40)
Masonry walls	m³/md	0.5	ILO (CTP 40)
Drifts (dry masonry)	No./md	1.5	ILO (CTP 40)
Concrete mix & pour	m³/md	0.5	ILO (CTP 40)
Setting out	m/md	100	ILO (CTP 40)
Haul - w/barrow (100m)	m³/md	2.2	WB, Tab F-5
- tractor/trailer (3km)	m³/mcd	18	Appendix N
- truck 3km	m³/mcd	24	WB, Fig F-10

WB: World Bank (Coukis et al, 1983)
ILO (CTP 40): World Employment Programme (Ghana), (de Veen, 1985)
- Average management and incentives
md = man-day
mcd = machine-day

Table K3: Adjustment factors applied to standard productivity data (According to Coukis et al, 1983: Table 7.7)

AUTHORITY	MANAGEMENT QUALITY (REFER TOTABLE 6.8) (1)	ENVIRONEMENTAL CONDITIONS (2)	PAYMENT SYSTEM	FACTORS (f) (See below)
KWZ	Good	Good	Daily	0.75
QWA	Good	Fair	Piecework	1.5
GAZ	Poor	Fair	Daily	0.33
KWD	Good	Good	Taskwork	1.5
LEB	Good	Good	Daily	0.75
BOP	Fair	Good	Daily; Taskwork	0.75
VEN	Poor	Fair	Daily	0.33
CIS	Fair	Good	Taskwork	1.25
TRN - OMC	Poor	Fair	Taskwork	0.75
- DWE	Fair	Fair	Daily	0.5
- DAF	Poor	Good	Daily	0.5

(1) Supervision and quality control
(2) See note below Table K4

Table K4: Range of adjustment factors applied to standard productivity data (Coukis et al, Table 7.7 1983)

PAYMENT SYSTEM	AREAS WITH LITTLE OR NO EXPERIENCE IN LI CONSTRUCTION
Daily paid	0.25 – 0.75
Taskwork	0.5 – 1.5
Piecework	1 – 3 (Upper limit will be taken as 2 due to insufficient planning time)

NOTE: The top end of the range in Table K4 has been used in Table K3 where management and/or environmental conditions have been more than satisfactory. Consequently the reverse applies to poor conditions. The conditions recorded on site visits by the author include: site/human environment as well as climate i.e. temperature, rainfall, drought, type of work, terrain, traffic interference, nutrition, local violence and so forth.

Table K5: Productivity ratings (Pr-1) per authority per activity (Assessment 1)

ACTIVITY	UNIT	KWZ	QWA	LEB	KWD	GAZ-VEN	BOP	CIS	TRN-OMC	TRN-DWE	TRN-DAF	%
Site clearance(grubbing)	m²/md	2	1			1	3	5			3	50
Excavation - loose	m³/md	4	2	1		3	2	1	2	5	3	51
- stiff	m/md		2	2	1		2		2		3	40
Loading (1m rise)	m³/md	5	5				3	2		5	5	83
Unloading (300mm)	m³/md	5	4				2	2				65
Spreading / shaping	m³/md	5	1			3	3	1	1	2	3	48
Watering: cart (4000L)	m²/md		1		1		1					20
: cans (20L)	m²/md							2				
Compaction - v roller (200 kg)	m³/mcd		5		5		5			5	5	100
- tamper 75 mm	m³/md							2				40
Grouted stone pitching	m³/md		4		5					4		87
Loose stone packing	m³/md	5		2		5		5		4		84
Pipe laying	m/md	5	5	5	3	5				5		93
Rock Collection 91km)	m³/md	2	2	1				1				30
Masonry walls	m³/md		5	5				5	5	5		100
Drifts (dry masonry)	No./md	1	2		1	2	1		5	4		46
Concrete mix & pour	m³/md		5	5	5	5				5		100
Setting out	m/md	5					3					80
Haul - w/barrow 100m	m³/md		3					2				50
- tractor/trailer (3km)	m³/mcd						5	1				60
- truck (3km)	m³/mcd				5			3	5			87
Rating (%)		75	63	60	65	69	55	49	67	86	73	66

Where:

Pr	Range
5	$Pa \geq fPn$
4	$0.75fPn \leq Pa < fPn$
3	$0.5fPn \leq Pa < 0.75fPn$
2	$0.25fPn \leq Pa < 0.5fPn$
1	$0 \leq Pa < 0.25fPn$

Pa = productivity achieved (Table K1)
Pn = productivity norm (Table K2)
f = factor (Table K3)
Pr-1 = productivity rating (/activity)

Table K6: Productivity achieved in Kenya (de Veen, 1983) and Malawi (Relf, Hagen and Akute, 1987)

ACTIVITY	UNIT	PRODUCTIVITY RANGE	AVERAGE	SOURCE
Site clearance (grubbing)	m²/man-day	100-250	175	K.R.A.R.P
Excavation - loose	m³/man-day	5-6	5.5	K.R.A.R.P
- stiff	m³/man-day	3.5-4.5	4	K.R.A.R.P
Loading – 1m rise (loose)	m³/man-day	12-15	13.5	K.R.A.R.P
Haulage – w/barrow (100m)	m³/man-day	5.5-7	6.3	K.R.A.R.P
Spreading / shaping	m³/man-day	12	12	K.R.A.R.P
Compaction – tamper	m³/man-day	12-15	13.5	K.R.A.R.P
Pipe laying	m /man-day	1.7	1.7	D.R.I.M.P
Masonry walls	m³/man-day	1.3	1.3	D.R.I.M.P
Concrete mix & pour	m³/man-day	1.6	1.6	D.R.I.M.P
Grouted stone pitching	m³/man-day	1.75	1.75	D.R.I.M.P
Loose stone packing	m³/man-day	3	3	D.R.I.M.P

Table K7: Productivity rating (Pr-2) Assessment 2

ACTIVITY	UNIT	KWZ	QWA	LEB	KWD	GAZ & VEN	BOP	CIS	TRN-OMC	TRN-DWE	TRN-DAF	%
Site clearance (grubbing)	m³/md	1	1	-	-	1	2	4	-	-	1	33
Excavation - loose	m³/md	3	2	1	-	1	2	1	1	2	1	31
- stiff	m³/md	-	2	1	1	-	1	-	1	-	1	23
Loading – 1m rise (loose)	m³/md	2	2	-	-	-	1	1	-	1	1	27
Haulage – w/barrow (100m)	m³/md	-	2	-	-	-	-	1	-	-	-	30
Spreading / shaping	m³/md	5	1	-	-	1	3	1	1	1	-	37
Compaction – tamper	m³/md	-	-	-	-	-	-	1	-	-	-	-
Pipe laying	m/md	2	2	1	1	4	-	-	-	3	-	43
Masonry walls	m³/md	-	4	5	-	-	-	3	4	1	-	68
Concrete mix & pour	m³/md	-	4	4	5	2	-	-	-	2	-	68
Grouted stone pitching	m³/md	-	2	-	5	-	-	-	-	1	-	53
Loose stone packing e.g. drifts	m³/md	2	1	1	1	2	1	5	2	1	-	36
Rating (%)		50	42	43	52	37	33	43	36	30	20*	41

NOTE:

md = man-day
*Transkei (D.A.F): Too few activities were monitored for an accurate assessment to be made.

L: ROADWORKS

Source: Watermeyer R(ed) Contractor Development in Labour-based Construction

Since task work forms the basis of measurement and payment in labour-based construction work, construction rates need to be assessed at an early stage of a project. Pilot schemes (small scale, trial or demonstration projects) can be run before the main project to determine these rates. A recent road building pilot project undertaken in Soweto yielded the following production rates for a contractor employing 25 labourers:

Activity	Daily Production (production / contractor/day)	Task (production / labourer/day)
Soft excavation	80,0 m³	3,2 m³
Intermediate excavation	40,0 m³	1,6 m³
Loading and carting away of spoil	137,5 m³	5,5 m³
Leveling of road bed	1 500,0 m²	60,0 m²
Picking of road bed	1 000,0 m²	40,0 m²
Compaction of road bed	500,0 m²	-
Construction of kerbing:		
straight	162,5 m	6,5 m
curved	50,0 m	2,0 m
Spreading of waterbound macadam	1 250,0 m²	50,0 m²
Leveling of waterbound macadam	625,0 m²	25,0 m²
Spreading of fines (dry processing)	1 250,0 m²	50,0 m²
Compacting of waterbound macadam	500,0 m²	20,0 m²

M: EARTHWORKS

Source: **Steidl D. Productivity Norms for Labour-Based Construction ASSIST Information Service Technical Brief No. 2 International Labour Organisation 1998.**

Table M1: Soil excavation characteristics

Activity definition	**Soil description**		**Suitable tools**
	Cohesive	*Non-cohesive*	
Soft	Soft	Very loose	Easily excavated with a shovel or hoe
Medium	Firm	Loose	Can be dug with a shovel
Hard	Stiff	Compact	Mattock, pick or other swung tool required
Very hard	Very stiff or hard	Dense or very dense	Crowbar required in addition to pick
Rock		Rock	Sledge hammer and chisels required

Table M2: Site clearing norms – country data

	Average productivity by type of cover m² per worker day				
Country	*Dense bush*	*Medium bush*	*Light bush*	*Grubbing*	*De-stumping*
Botswana	—	750	750	150	—
Cambodia	30	60	100	15	0.75
Ghana	—	—	375	375	—
Indonesia	130	175	—	37.5	1
Kenya	50	150	300	100	—
Lesotho	50	100	250	65	—
Tanzania	50	100	250	150	3.5
Zimbabwe	200	—	300	250	—
WB Study	—	—	150	15	—
Median	**50**	**125**	**275**	**100**	**1**

Table M3: Site clearing norms – recommended values

	Average productivity by type of cover m² per worker day				
	Dense bush	*Medium bush*	*Light bush*	*Grubbing*	*De-stumping*
Country median	50	125	275	100	1
Site trials	105	209	311	209	—
RARP	320	480	640	I75	—
Recommended value	**100**	**200**	**350**	**175**	**By experience**

Table M4: Excavation norms – country data

Country	Average productivity by soil classification m³ per worker day				
	Soft	*Medium*	*Hard*	*Very hard*	*Rock*
Botswana	4.15	3.8	2.5	1.9	—
Cambodia	2.75	2	1.25	0.75	—
China	9	7.0	3	2	—
Ghana	3.75	3.75	3.75	3.75	—
Indonesia	—	—	2.5	—	—
Kenya	5	3.5	2.25	1.75	0.75
Lesotho	4.5	3.5	2.75	1	0.5
Nepal	—	3.3	2.5	—	0.61
Tanzania	5.5	4.5	4	2.5	—
Zimbabwe	5.5	5.5	4	3.5	2
WB Study	6.7	2.1	3	2	1.7
Median	**5.00**	**3.50**	**2.75**	**2.00**	**0.75**

Table M5: Excavation norms – recommended values

	Average productivity by soil classification m^3 per worker day				
	Soft	*Medium*	*Hard*	*Very hard*	*Rock*
Country median	5.00	3.50	2.75	2.00	0.75
Site trials	3.6	3.2	3.45	2.2	0.8
RARP	5.5	4	3	2	—
Recommended value	**5.0**	**3.5**	**3.0**	**2.0**	**0.8**

Table M6: Wheelbarrow haulage norms – country data

Country	Wheelbarrow haulage norms by haul distance m^3 per worker day					
	0-20m	*20-40m*	*40-60m*	*60-80m*	*80-100m*	*100-150m*
Botswana	8.4	7	6.7	5.6	5.2	4.7
Kenya	10.5	10.5	8	6.5	5.5	4.5
Lesotho	8	6	5	4.5	4	—
Tanzania	11	11	8.25	6.25	5.25	5
Zimbabwe	5	5	5	5	5	4
Median	**8.4**	**7**	**6.7**	**5.6**	**5.2**	**4.6**

Table M7: Wheelbarrow haulage norms – recommended values

	Wheelbarrow haulage norms by haul distance m³ per worker day					
	0-20m	*20-40m*	*40-60m*	*60-80m*	*80-100m*	*100-150m*
Country median	8.4	7.0	6.7	5.6	5.2	4.6
Site trials	5.3	4.8	4.6	4.3	4.2	4.1
RARP	13.5	10.5	8.5	6.5	5.5	—
Recommended value	**8.5**	**7.0**	**6.5**	**5.5**	**5.0**	**4.5**

Table M8: Typical haulage rates for manually loaded equipment

Haul route condition	Good					Average					Poor				
Haul distance (km)	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10
Trips per day per truck	22	19	16	11	8	18	15	12	8	6	16	12	10	7	5
Trips per day per tractor/trailer combination	20	12	8	6	4	18	11	6	5	4	16	9	4	4	3

Table M9: Loading, unloading and spreading norms – country data

Country	Average productivity rates m³		
	Loading	*Unloading*	*Spreading*
Botswana	12	—	14
Cambodia	8	15.5	5.25
Ghana	6.7	10	—
Kenya	10	9	13.5
Lesotho	5	—	14.25
Tanzania	11	—	15
Zimbabwe	8.5	—	9
World Bank	—	—	11
Median	**8.5**	**10**	**13.5**

Table M10: Loading, unloading and spreading norms – recommended values

	Average productivity rates m³ per worker day		
	Loading	*Unloading*	*Spreading*
Country median	8.5	10	13.5
Site Trials	6.5	11	12
RARP	8.5	—	13.5
Recommended value	**8.5**	**10**	**13.5**

Table M11: Compaction norms – country data and recommended values

Country	Manual compaction	Equipment compaction
	m^3 per worker day	*m^2 per roller day*
Cambodia	10	—
China	3.2	—
Kenya	7.5	700
Lesotho	15	700
Tanzania	9	700
Median	*9.0*	*700*
Recommended value	**9.0**	**700**

Table M12: Culvert laying norms – country data

Country	Activity		
	Culvert installation m per worker day	*Concrete m³ per worker day*	*Masonry m³ per worker day*
Cambodia	—	1.25	1.25
China	1.2	—	—
Kenya	0.3	1	1.5
Lesotho	1.1	1.75	1.35
Zimbabwe	0.8	0.8	0.75
Median	**0.9**	**1.13**	**1.3**

Table M13: Culvert laying norms – recommended values

Country	Activity		
	Culvert installation m per worker day	*Concrete m³ per worker day*	*Masonry m³ per worker day*
Country median	0.9	1.13	1.3
Site trials	0.95	0.6	0.6
Recommended value	**0.9**	**1.0**	**1.0**

Table M14: Typical equipment /labour combinations for gravelling

Haul distance *Km*	**Loads per day** *unit*	**Total volume** *Loose m^3*	**Excavation** *Workers per tractor*	**Loading** *Workers per tractor*	**Un-loading** *Workers per tractor*	**Spreading** *Workers per tractor*
0 to 2	18	54	18	7	6	4
2 to 4	11	33	11	4	4	2
4 to 6	7	21	7	3	2	2
6 to 8	5	15	5	2	2	1
8 to 10	4	12	4	2	1	1

Table M15: Summary of recommended values

SITE CLEARING

	Average productivity by type of cover m² per worker day				
	Dense bush	*Medium bush*	*Light bush*	*Grubbing*	*De-stumping*
Recommended value	**100**	**200**	**350**	**175**	**By experience**

EXCAVATION

	Average productivity by soil classification m^3 per worker day				
	Soft	*Medium*	*Hard*	*Very hard*	*Rock*
Recommended value	**5.0**	**3.5**	**3.0**	**2.0**	**0.8**

WHEELBARROW HAULAGE

Wheelbarrow haulage norms by haul distance m³ per worker day	0-20m	20-40m	40-60m	60-80m	80-100m	100-150m
Recommended value	**8.5**	**7.0**	**6.5**	**5.5**	**5.0**	**4.5**

LOADING, UNLOADING AND SPREADING

Average productivity rates m³ per worker day	*Loading*	*Unloading*	*Spreading*
Recommended value	**8.5**	**10**	**13.5**

COMPACTION

	Manual compaction	**Equipment compaction**
	m^3 per worker day	*m^2 per roller day*
Recommended value	**9.0**	**700**

CULVERT LAYING

	Culvert installation *m per worker day*	**Concrete** *m³ per worker day*	**Masonry** *m³ per worker day*
Recommended value	**0.9**	**1.0**	**1.0**

TYPICAL HAULAGE RATES FOR MANUALLY LOADED EQUIPMENT

Haul route condition	**Good**					**Average**					**Poor**				
Haul distance (km)	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10
Trips per day per truck	22	19	16	11	8	18	15	12	8	6	16	12	10	7	5
Trips per day per tractor/trailer combination	20	12	8	6	4	18	11	6	5	4	16	9	4	4	3

TYPICAL EQUIPMENT / LABOUR COMBINATIONS FOR GRAVELLING

Haul distance	**Loads per day**	**Total volume**	**Excavation**	**Loading**	**Un-loading**	**Spreading**
Km	*unit*	*Loose m^3*	*Workers per tractor*	*Workers per tractor*	*Workers per tractor*	*Workers per tractor*
0 to 2	18	54	18	7	6	4
2 to 4	11	33	11	4	4	2
4 to 6	7	21	7	3	2	2
6 to 8	5	15	5	2	2	1
8 to 10	4	12	4	2	1	1

Table M16: Average worker input for completed operations

Project	Operation	Input
	Construction of	*worker days/km*
Botswana	Earth road	1981
Botswana	Gravel topping only	2157
Ghana DFR	Gravel lowland road	1580
Kenya MRP	Earth lowland road	1442
Kenya MRP	Gravel topping only	1819
Kenya MRP	Regravelling	1209
Laos LAO/90/MO1/FRG	Gravel lowland road	2203
Lesotho LCU	Gravel lowland road	2645
Lesotho LCU	Gravel mountain road	4400
Zimbabwe LBDU	Gravel lowland road	3260

ANNEX 2: Country productivity data

Note: There are many gaps in the tables below. However, it is hoped that the publication and dissemination of this Brief will stimulate readers to contribute to filling in the gaps. If you have relevant data, please send it to one of the ASIST offices (see the back cover for addresses).

Table M17: Country data for site clearing activities

Production targets	**Bush clearing**						**Other clearing**					
	Dense		**Medium**		**Light**		**Grubbing**		**De-stumping**		**Boulder removal**	
Country	*m² Min*	*m² Max*	*m² Min*	*m² Max*	*m² Min*	*m² Max*	*m² Min*	*m² Max*	*No Min*	*No Max*	*No Min*	*No Max*
Botswana				750		750		150				
Cambodia	20	40	40	80	80	120	10	20	1	1		
China												
Ghana					350	400	350	400			5	15
India		130	150	200			30	45		1		
Kenya		50		150		300	0	200		Exp		Exp
Lesotho		50		100		250	30	100		1		Ds
Mozambique												
Tanzania		50		100		250		150	2	5	Ds	Ds
Thailand												
Zimbabwe		200				300	200	300			1	10
World Bank						150		15				
Minimum	20	40	40	80	80	120	0	15	1	1	1	10
Maximum	20	200	150	750	350	750	350	400	2	5	5	15
Average	20	87	95	230	215	315	103	153	1	2	3	13
Median	20	50	95	125	215	275	30	150	1	1	3	13
Number of records	1	6	2	6	2	8	6	9	2	4	2	2

Actual output	**Unit**	**Botswana**		**Ghana**		**Kenya**		**Lesotho**		**Mozambique**		**Zimbabwe**	
Clearing		*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*
Dense Bush	m2		17.4		33.9		11.3						
Medium Bush	m2		29.2		53.8		27.5						45
Light Bush	m2		35		64.9		52.5						65
Grubbing <20 cm	m2				27.5		31.3						75
De-stumping > 20 cm	No												
Boulder removal	No												

Ds = Depends upon the size; Exp = By experience

Table M18: Country data for excavation activities

Production targets for excavation in cubic metres per task										
	Soft		*Medium*		*Hard*		*Very hard*		*Rock*	
Country	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Botswana	3.8	4.5	3.1	4.5	2.5	2.5	1.9	1.9		
Cambodia	2.5	3.0	1.5	2.5	1.0	1.5	0.5	1.0		
China		9.0		7.0		3.0		2.0		
Ghana	3.0	4.5	3.0	4.5	3.0	4.5	3.0	4.5		
Indonesia			1.7	3.5		2.5				
Kenya	4.0	6.0	2.0	5.0	1.5	3.0	1.5	2.0	0.5	1.0
Lesotho	4.0	5.0	3.0	4.0	2.5	3.0	0.5	1.5	0.5	1.5
Mozambique										
Tanzania	5.0	6.0	4.0	5.0	3.5	4.5	2.0	3.0		
Thailand										
Zimbabwe	5.0	6.0	5.0	6.0	3.0	5.0	3.0	4.0	1.0	3.0
World Bank		6.7		4.2		3.0		2.0		1.7
Minimum	2.5	3.0	1.5	2.5	1.0	1.5	0.5	1.0	0.5	1.0
Maximum	5.0	9.0	5.0	7.0	3.5	5.0	3.0	4.5	1.0	3.0
Average	3.9	5.6	2.9	4.6	2.4	3.3	1.8	2.4	0.7	1.8
Median	4.0	6.0	3.0	4.5	2.5	3.0	1.9	2.0	0.5	1.6
Number of records	7	9	8	10	7	10	7	9	3	4

Actual output of excavation in cubic metres per task										
	Soft		*Medium*		*Hard*		*Very hard*		*Rock*	
Country	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*
Botswana	5.2	3.6	5.2	3.2	5.2	2.9				
Cambodia	6.0		6.0		6.0		6.0		6.0	
China	10.0		10.0		10.0		10.0			
Ghana	5.0	4.1	5.0	4.1	5.0	4.1	5.1	4.2		
Indonesia										
Kenya	4.0	3.0	5.0	2.5	5.0	2.0	1.5	1.3	5.0	0.9
Lesotho		3.3		2.9				1.4		0.7
Mozambique										
Tanzania										
Thailand										
Zimbabwe	5.0	5.0	5.0	4.5	5.0	4.0	5.0	3.0		
World Bank										
Minimum	4.0	3.0	5.0	2.5	5.0	2.0	1.5	1.3	5.0	0.7
Maximum	10.0	5.0	10.0	4.5	10.0	4.1	10.0	4.2	6.0	0.9
Average	5.9	3.8	6.0	3.4	6.0	3.3	5.5	2.5	5.5	0.8
Median	5.1	3.6	5.1	3.2	5.1	3.5	5.1	2.2	5.5	0.8
Number of records	6	5	6	5	6	4	5	4	2	2

Table M19: Country data for haulage activities

Production targets for hauling in cubic metres per task												
	0-20 m		*20-40 m*		*40-60 m*		*60-80 m*		*80-100 m*		*100-150 m*	
Country	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Botswana		8.4		7.0		6.7		5.6		5.2		4.7
Cambodia												
China												
Ghana												
Indonesia												
Kenya		10.5		10.5		8.0		6.5		5.5		4.5
Lesotho		8.0		6.0		5.0		4.5		4.0		-
Mozambique												
Tanzania	10.0	12.0	10.0	12.0	7.5	9.0	6.0	6.5	5.0	5.5		5.0
Thailand												
Zimbabwe		5.0		5.0		5.0		5.0		5.0		4.0
World Bank												
Minimum	10.0	5.0	10.0	5.0	7.5	5.0	6.0	4.5	5.0	4.0	0.0	4.0
Maximum	10.0	12.0	10.0	12.0	7.5	9.0	6.0	6.5	5.0	5.5	0.0	5.0
Average	10.0	8.8	10.0	8.1	7.5	6.7	6.0	5.6	5.0	5.0	0.0	4.6
Median	10.0	8.4	10.0	7.0	7.5	6.7	6.0	5.6	5.0	5.2	0.0	4.6
Number of records	1	5	1	5	1	5	1	5	1	5	0	4

Actual output of excavation in cubic metres per task												
	0-20 m		*20-40 m*		*40-60 m*		*60-80 m*		*80-100 m*		*100-150 m*	
Country	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*
Botswana	5.0	6.0	5.0	5.0	5.0	4.5	5.0	4.0	5.0	3.8	5.0	3.3
Cambodia												
China												
Ghana	5.9	4.6	5.9	4.6	5.9	4.6	5.9	4.6	5.9	4.6	5.9	4.6
Indonesia												
Kenya												
Lesotho		3.5		3.5		3.5		3.5		3.5		3.5
Mozambique												
Tanzania												
Thailand												
Zimbabwe	5.0	9.0	5.0	9.0	5.0	8.0	5.0	7.0	6.0	6.0	6.0	5.0
World Bank												
Minimum	5.0	3.5	5.0	3.5	5.0	3.5	5.0	3.5	5.0	3.5	5.0	3.3
Maximum	5.9	9.0	5.9	9.0	5.9	8.0	5.9	7.0	6.0	6.0	6.0	5.0
Average	5.3	5.8	5.3	5.5	5.3	5.2	5.3	4.8	5.6	4.5	5.6	4.1
Median	5.0	5.3	5.0	4.8	5.0	4.6	5.0	4.3	5.9	4.2	5.9	4.1
Number of records	3	4	3	4	3	4	3	4	3	4	3	4

Table M20: Country data for loading, unloading and spreading activities

Production targets		**Botswana**		**Cambodia**		**China**		**Ghana**		**Indonesia**		**Kenya**	
Load, unload, spread	*Unit*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Loading soil	m3		12	8	12							8	10
Loading gravel	m3			5	7				6.7			8	10
Unloading soil	m3			15	20							8	10
Unloading gravel	m3			12	15				10			8	10
Spreading soil	m3		10	5	7.5							12	15
Spreading soil	m2								50		60		
Spreading gravel	m3		18	3.5	5							12	15
Spreading gravel	m2							50	75	35	50		

Production targets		**Lesotho**		**Mozambique**		**Tanzania**		**Thailand**		**Zimbabwe**		**World Bank**	
Load, unload, spread	*Unit*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Loading soil	m3					12	15						
Loading gravel	m3		5			7	10			8	9		
Unloading soil	m3												
Unloading gravel	m3												
Spreading soil	m3	14	16			15	18			7	10		11
Spreading soil	m2		90			60	90						
Spreading gravel	m3	12	15				12				10		
Spreading gravel	m2		60				60						

Actual output		**Botswana**		**Cambodia**		**China**		**Ghana**		**Indonesia**		**Kenya**	
Load, unload, spread	*Unit*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*
Loading soil	m3			6								6	9
Loading gravel	m3			6				6.25	6.5			6	9
Unloading soil	m3			6									9
Unloading gravel	m3			6					12.7			6	9
Spreading soil	m3			6									
Spreading soil	m2							5.4	91			6	13
Spreading gravel	m3			6								6	13
Spreading gravel	m2							5.8	86				

Actual output		**Lesotho**		**Mozambique**		**Tanzania**		**Thailand**		**Zimbabwe**		**World Bank**	
Load, unload, spread	*Unit*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*
Loading soil	m3									5	6		
Loading gravel	m3									5	6		
Unloading soil	m3									5	11		
Unloading gravel	m3									5	11		
Spreading soil	m3									5	11		
Spreading soil	m2												
Spreading gravel	m3									5	11		
Spreading gravel	m2												

Table M21: Country data for compaction activities

Production targets	Handrammer					
	Formation		*Structures*		Slopes	
	m³		*m³*		*m³*	
Country	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Botswana						
Cambodia	10.0	12.5			7.5	10.0
China		5.7		2.5		1.5
Ghana						
Indonesia						
Kenya			6.0	9.0	6.0	9.0
Lesotho						
Mozambique						
Tanzania	8.0	10.0				
Thailand						
Zimbabwe						
World Bank						
Minimum	8.0	5.7	6.0	2.5	6.0	1.5
Maximum	10.0	12.5	6.0	9.0	7.5	10.0
Average	9.0	9.4	6.0	5.8	6.8	6.8
Median	9.0	10.0	6.0	5.8	6.8	9.0
Number of records	2	3	1	2	2	3

Production targets	Mechanical											
	Formation		*Structures*		Slopes		*Structures*		Slopes		*Structures*	
	m³		*m³*		*m³*		*m²*		*m²*		*m²*	
Country	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Botswana												
Cambodia	75.0	100.0			10.0	13.5						
China		16.7										
Ghana												
Indonesia												
Kenya												
Lesotho	100.0	150.0						700.0				
Mozambique												
Tanzania		140.0						700.0				
Thailand												
Zimbabwe		250.0										
World Bank	170.0	280.0										
Minimum	75.0	16.7			10.0	13.5	0.0	700.0				
Maximum	170.0	280.0			10.0	13.5	0.0	700.0				
Average	115.0	156.1			10.0	13.5	0.0	700.0				
Median	100.0	145.0			10.0	13.5	0.0	700.0				
Number of records	3	6			1	1	0	2				

Table M22: Country data for culvert laying activities

Production targets		Botswana		Cambodia		China		Ghana		Indonesia		Kenya	
Compaction	*Unit*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Culvert laying													
600 mm	m			6	12		1.4						0.33
900 mm	m						0.9						0.33
Concrete work	m3			1	1.5	0.1	0.2						1
Stone masonry	m3			1	1.5								1.5

Production targets		Lesotho		Mozambique		Tanzania		Thailand		Zimbabwe		World Bank	
Compaction	*Unit*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Culvert laying													
600 mm	m	1	1.1				0.36			0.5	0.9		
900 mm	m												
Concrete work	m3	1.5	2							0.6	1		
Stone masonry	m3	1.2	1.5							0.5	1		

Actual output		Botswana		Cambodia		China		Ghana		Indonesia		Kenya	
Compaction	*Unit*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*
Culvert laying													
600 mm	m			7								5	
900 mm	m												
Concrete work	m3			7								6	0.28
Stone masonry	m3			7								6	0.3

Actual output		Lesotho		Mozambique		Tanzania		Thailand		Zimbabwe		World Bank	
Compaction	*Unit*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*	*Hr/task*	*Max*
Culvert laying													
600 mm	m	7	1								0.9		
900 mm	m	7	0.8										
Concrete work	m3	7	0.5								1		
Stone masonry	m3	7	0.5								1		

N: TASK OUTPUT RATES

Source: Department of Public Works: Guidelines for enhancing employment opportunities in the delivery of infrastructure projects – a national Public Works Programme Initiative

1. Indicative production rates for selected activities

The following production rates are presented as a guide only. Actual production rates may vary, depending on local conditions.

Table N1: Task output rates

ACTIVITY	DESCRIPTION	UNIT	PRODUCTION RATES (Various sources)	RECOMMENDED PRODUCTION RATE
Clear and grub	Clearing	m²	150 250 150 300-800	150-300
	Clearing and grubbing	m²	150 60 80 100 180	- 80-150
Excavation	Trenches (± 0.5 m wide) (0.0 m to 1.0 m deep)	m	9.5 7.5 10	7-10
	Trenches (± 0.5 m wide) (1.0 m to 1.25 m deep)	m	7.0 5.5 6.0	5-7
	Trenches (normal trench width and depth)	m³	6.0 5.6 4.5 2.5 2.0 3.5	3-6
EXCAVATION	Earthworks - Soft class 1 soil) (In wider excavations double handling might have to be allowed for)	m³	4.0-5.5 4.8 2-5.5 4.0 2.8-3.2 3.0 2.3 6.0 5-12 2.5-5.0 3.0-4.0 4.8-5.5 3.0 2.5 3.5 3.3 2.0-4.0 1.6-2.4 2.0-3.0	2,5-5,0
	- Intermediate (soil) (In wider excavations double handling might have to be allowed for)	m³	2.5-3.5 3.3 4.0 2.5 2.0	2.0-3.0
	- Hard (soil) (In wider excavations double handling might have to be allowed for)	m³	2.1-2.2 2.0 1.6 0.5-2.0	1.0-2.0
BORROWPITS	Select and load rock Feed crusher Load gravel	m³ m³ m³	2 3.5 6	2 3.5 6
SPREADING	Earthworks	m³	12.0 7.0 12.0-16.0	7.0-12.0

	Remove oversize material Verge (incl. Compaction)	m^3 m^3	2.5 4.7	2-3 4-5
Hauling	Wheelbarrow 0m-20m 40m-60m 60m-80m 80m-100m	m^3 m^3 m^3 m^3	13.5 10.5 10.5 8.0 8.0 6.5 7.0 5.0	10-13 8-10 6-8 5-6
Backfilling	Trenches Excavations	m^3 m^3	4.0 10.5 2.0-5.0	4-8 2-5
Waterbound Macadam (WBM)	Construct Spread coarse material Spread and broom fines	m^3 m^3 m^3	0.8 0.6 0.16 4.7 4.7	 0.5-0.8 4.7 4.7
Surfacing	Sweep basecourse Spread chips and backchip Slurry mix and spread Spread asphalt	m^3 m^2 m^3 m^3	490 1 000 300 200-400 1.5 0.67 0.4	1 000 200-400 0.8-1.2 0.4
Concrete blocks	Laying of blocks	m^2	20 17	15-20
Kerbs	Laying of pre-cast	m	10 26	10-20
Manhole construction	Place precast manhole rings (300 mm high) Mix and place benching Place precast manhole cover-slabs	no. no. no.	4.5 2 2.5	4.5 2 2.5
Concrete	Mixing Placing	m^3 m^3	0.7-3.0 1.1-4.0	0.7-1.5 1.0-4.0
Roadmarking	Painting (100 mm line)	m	150	150
Pipe laying	100-150 mm diameter sewer 100-150 mm diameter water HDPE water pipe	m m m	19-24 14-19 125	19-24 14-19 125

O: TYPICAL TASK RATES

Source: **McCutcheon and Marshall. Labour-intensive construction and maintenance of rival roads: Guidelines for the training of road builders. Construction and Development Series, November 14, Development bank of Southern Africa. Development Paper 60, November 1996.**

Table O1: Average task output values

Operation	Activity	Minimum Task
Site clearance	Bush clearing – dense light to medium	Determine on site
	Stripping and grubbing	150m^2 - 750m^2/day
	Tree and stump removal	100m^2 - 200 m^2/day
	Boulder removal	Experience
		200 day/km
Earthworks	Slotting	4m^3/day
	Excavation to level	
	Cute < 0,25 m	5m^3/day
	> 0,25 m	4m^3/day
	Borrow to fill	4m^3/day
	Haulage (wheelbarrow)	
	0-20 m	13,5m^3/day
	40-60m	8,0m^3/day
	80-100m	5,5m^3/day
	Spreading	12m^3/day
Drainage	Ditching	3,75m^3/day
	Sloping	3,75m^3/day
	Camber formation	100m^2 /day
	Mitre drains	3,75m^3/day
	Catchwater drains	3,75m^3/day
	Scour checks	25/day
	Culvert installation	max. 20 days/line
Gravelling	Excavation	3m^3/day
	Load	6m^3 (loose)/day
	Spreading	12m^3/day

Source: McCutcheon (1983) and Simpson (1980)

Table O2: Detailed task rates for excavation

Soul Type	Tools	Task rates (m^3/man-day)		
		Throwing distance (m)		
		0-4	4-6	6-8
Loose, not sticky soil	Shovel, jembe	5,0-6,0	4,5-5,5	3,5-4,5
Firm soil	Shovel, for k jembe	3,5-4,5	3,0-4,0	2,5-3,5
Very hard soil, hard soil mixed with stones	Pickaxe, fork jembe, shovel	2,0-3,0	1,8-2,5	1,7-2,5

Source: De Veen (1980, 1983)

Table O3: Resource inputs, example from Lesotho

Ref	Work item	Unit	Labour m.d	Plant						Materials			
				tpd	rd	ftd	Spray day	cd	Mixer day	Cement pkt	Stone cu.m	Bitume drum	Weldimesh sq/m
1	Formation work												
	Excavation 1500 cu m/km	km	1280										
	2000 cu m/km	km	1480										
	2500 cu m/km	km	1730										
	3000 cu m/km	km	1980										
2	Gravelling -haul = 0-2 km	km	823	14	10								
	5m wide	km	1025	20	10								
	-haul = 2-7 km	km	1175	41	10								
3	5m wide												
	-haul = 7-20 km												
	5m wide												
	Road maintenance												
	(lengthmen system)												
4	Dry stone masonry	cu.m	2,5										
	=w.bhaul of stone	cu.m	2	0,065									
5	=tphaul												
	of stone	cu.m	3,7	0,022						1,7			
	Cement bound	cu.m	3,1	0,098						1,7			
6	Stone masonry	cu.m	3,5	0.091						7			
	=w.bhaul of stone & sand	cu.m	3	0,161						7			
7	=tphaul	cu.m	3,7	0,065						5			
	of stone & sand	cu.m	3,1	0,141					9	5			
8	1:2:4 concrete	km	336						5,6				
9	=w.bhaul of stone & sand	km	224										
10	=tphaul	lin.m	1										
	of stone & sand	lin.m	0,84	0,007				0,5					
	1:3:6 concrete			0,029				0,5					
	=w.bhaul of stone & sand												
	=tphaul												
	of stone & sand												
	Track excavation												
	Ditch excavation												
	Ditch lining =w.bhaul												
	of stone & sand												
	=tphaul												
	of stone & sand												
11	Grassing	sq.m	0,1			,006	,003						
12	Gabions =w.bhaul	cu.m	3,2		0,05								
	of stone	cu.m	2,7		0,12								
	=tphaul												
	of stone												
13	600 pipe culvert	per culv	11		0,3								
	900 pipe culvert	per culv	12		0,5								
14	Stone slab culvert	per culv	42		0,212					8			
	=w.bhaul of stone & s and	per culv	41		0,374					8			

15	=tphaul	per culv	6		0,039					3			
	of stone & sand	per culv	5		0,185					3			
	Culvert headwalls =w.bhaul												
	of stone & sand												
	=tphaul												
	of stone & sand												
16	Vented ford =w.bhaul	lin.m	29		0.53					44			2 shts
	of concrete	lin.m	25		1,05					44			2 shts
17	=tphaul	lin.m	18		0,3				0,25	25			2 shts
	of stone & sand	lin.m	15		0,63				0,25	25			2 shts
18	Vented ford (rock) =w.bhaul	per arch	63,3		1,1					76			16,2
	of stone & sand	per arch	54,7		2,26					76			16,2
19	=tphaul of	m/bridge	51		0,26					20			
	stone & sand	m/bridge	44		1,18					20			
20	Minibridge =w.bhaul	per arch	731		12					800			
	of stone & sand	per arch	635		25					800			
21	=tphaul	per struc	375		2					150			
	of stone & sand	per struc	323		9					150			
	(wingwalls) =w.bhaul												
	of stone & sand												
	=tphaul of												
	stone & sand												
	Pipe arch =w.bhaul												
	of stone & sand												
	=tphaul of												
	stone & sand												
	(wingwalls) =w.bhaul												
	of stone & sand												
	=tphaul of												
	stone & sand												
22	Lime stab base =gravel	km	1589		14	20				2500li			
	hl=0-2km 5m wide	km	1800		20	20				2500li			
	=gravel	km	1950		41	20				2500li			
23	hl=2-7km 5m wide	km	56				2				20	48	
24	=gravel	km	630			20	25	35			107	123	
25	hl=7-20 5m wide	km	830			10	15	25		10	99	87	
	Thickened edge (bitumen												
	surfacing)												
	Double seal surfacing												
	Cape seal surfacing												
26	Concrete blocks (production)	100 blocks	4,1		0,065					5,1			
27	Concrete blockwork	100 sq.m	7+4,5*		2,05					71			
28	(building)	cu.m	3+2,5*		0,105					1,7			
29	Random rubble masonry	100 sq.m	3,3+8*		0,062					3,4			
30	(building)	100 lin.m	30							14			
	Pointing (masonry)												
	Security fencing						0,5						

sq.m square meters cu.m cubic metres quantity m.d. man-day tpd tipper day std spray truck day	m² st m² stone db drum bitumen ftd flat truck day bp budge productivity cl collect and load h haul	lu load & unload cd day lpkt lime packet sqmwm sq.m weldmesh mp mix and place lh load and haul	rd roller day sc spread and compact bit. bitumen emulsion cpkt cement packet swm sweet weldmesh

* Skilled labour
Source: Extracted from Taylor, 1987. Labour-Construction Unit; Scott Wilson Kirkpatrick

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Appendix 2: Implementing employment intensive infrastructure projects which target the increase of employment opportunities generated per unit of expenditure

(Annex G of SANS 10396: *Implementing Preferential Construction Procurement Policies using Targeted Procurement Procedures*)

G1 Introduction

Changes in methods and technologies, which increase the labour component in construction and the manufacture of materials, yield the greatest increase in the number of employment opportunities generated per unit of expenditure. This requires established companies to reduce their reliance on capital intensive technologies. Suitable methods and technologies are usually readily implemented by small scale enterprises, who by being small, have limited access to capital and invariably operate and conduct their businesses in a more employment-intensive fashion and favour light, non-equipment-based forms of construction.

Various statistics have been put forward to quantify the impact of introducing employment-intensive construction practices. Many of them relate to the methods of measurement which are adopted. The following parameters are commonly used to evaluate employment-intensive construction practices:

The multiplier in employment opportunities (i.e. the ratio of the total number of personhours generated in the construction of a specified structure, service or activity using labour-based technologies, to that using plant-based technologies).
Expenditure per unit of employment generated (i.e. the ratio of total construction costs excluding VAT but including any management fees directly related to construction activities to total volume of employment-generated (manhours) in the construction of a structure or service.
Construction expenditure retained within the community.

This informative annex focuses on the use of the SANS 1914-5 targeted construction procurement (Participation of Targeted Enterprises) standard to encourage cost effective employment intensive practices.

NOTE : The fundamental difference between the SANS 1914-4 targeted construction procurement standard (Participation of Targeted Enterprises and Targeted Labour (Local Resources)) and the SANS 1914-5 standard (Participation of Targeted Labour) is that the former targets enterprises and labour whereas the latter targets only labour. Many of the techniques presented in this Annex can also be applied to the targeting of labour in terms of the SANS 1914-4 standard.

G2 Defining targeted labour

Increases in employment opportunities generated per unit of expenditure on infrastructure projects can best be achieved by targeting unskilled / semi-skilled labour. Targeted labour may accordingly be defined in terms of statutory wage rates, e.g., persons who earn not more than one and a half times the minimum statutory wage rate. In some instances, there may be merit, in the interests of local economic development, to include residency within a broad geographical area in the definition.

SAMPLE DEFINITION
South African citizens who permanently reside within the boundaries of t .... and earn wages and allowances amounting to less than R......... per hour. It is incumbent on individuals to demonstrate their claims to such residency on the basis of identification and association with and recognition by members of the community residing within the aforementioned areas.

G3 Encouraging contractors to make more use of targeted labour in excavation activities

In order to meet goals for the engagement of targeted labour, or to tender increased contract participation goals, contractors may have to undertake some, or all, soft excavations by the use of hand labour. In order to minimise their risk exposure in performing such activities, there needs to be :

a labour policy in place which sets out the conditions of employment for temporary workers (i.e. project specific workers)

a mechanism in terms of which contractors can define the portion of the excavation works which will be excavated by hand methods.

If this is not done, contractors will not be able to increase job opportunities in earthworks activities as they would be exposed to unacceptable risks. The abovementioned employment policy and mechanism should accordingly be clearly set out in the tender documents and form an integral part of the contract.

The conditions of employment pertaining to the employment of temporary workers (i.e. project specific workers) can be described in the Works Information. (These conditions will not be necessary should project specific workers be engaged in terms of statutory labour provisions. It may, however, in certain circumstances be desirable to vary such provisions in order to increase the participation of targeted lanour, in which case such conditions should be fully described.). SANS 1914-5 requires contractors to enter into formal contracts with targeted labour. Credit towards the attainment of contract participation goals can be denied should contractors fail to engage targeted labour in accordance with the conditions of employment as laid down in the Works Information.

A suitable mechanism to enable contractors to define portions of excavation work which may be carried out by hand methods is to permit contractors during the tender stage to nominate the quantity of materials which they wish to excavate using hand methods. The approach outlined below is suggested.

The initial classification of material to be excavated should be in accordance with the relevant provisions of a standard system of measurement. However, soft excavation to be undertaken by hand labour, using hand tools, can be further broken down by the introduction of an additional class of material, viz., soft excavation Class A, in accordance with the provisions of the Contract Prices as follows :

Criteria for classifying material as soft excavation Class A *		
Dynamic cone penetrometer - minimum number of blows required to penetrate 100 mm	Granular materials	Cohesive materials
	7-15 +	6 to 8 +
Consistency	Dense - high resistance to penetration by the point of a geological pick; several blows required for removal of material.	Stiff / Very stiff Stiff - can be indented by thumb-nail; slight indentation produced by pushing geological pick point into soil; cannot be moulded by fingers. Very stiff - indented by thumb-nail with difficulty; slight penetration of point produced by blow of geological pick.

* Soft excavation Class A is material which, using a pick or equivalent hand swing tool, can only be excavated with difficulty.

The total estimated quantity of excavation, as classified in terms of a standard system of measurement, should be indicated in the Contract Prices. The contractor should be permitted to sub-divide this quantity into two components, viz., the quantity of material to be excavated by the use of powered, mechanical equipment and the quantity to be excavated by hand labour using hand tools.

One third (1/3) of every quantity of excavation to be undertaken by hand labour should be entered against the appropriate extra-over items provided in the Contract Prices, but left blank, for soft excavation Class A. This will ensure that material which can be picked with difficulty is catered for and the transition from hand excavation to machine excavation is graded.

Should the contractor fail to indicate a quantity of excavation to be undertaken by hand labour, notwithstanding that he would find it necessary to utilize hand labour, it will be assumed that all excavation, whether undertaken by machine, or by hand labour, is to be paid for at the rates tendered for machine excavation.

The contractor, should be required to undertake at least the quantities of excavation by hand labour which he tendered, unless the total quantity of excavation proves to be less than scheduled, in which case the minimum quantity to be undertaken by hand labour will be reduced pro-rata by the Employer's Representative. This procedure will also provide a basis for reducing contract participation goals should such adjustments be necessary.

Should the total quantity of excavation prove to be greater than that scheduled, the contractor may choose the method of excavation for the excess quantity, unless the rates for excavation by machine would result in lower costs than for hand excavation, in which case the Employer's Representative will have the right to instruct the contractor to undertake the excavation by machine.

Insert the following into the conditions of tender:
SOFT EXCAVATION
In order to meet goals for the engagement of Targeted Labour, the Tenderer may intend to undertake some, or all, soft excavations by the use of hand labour.
The initial classification of material to be excavated shall be in accordance with the relevant provisions of ……...
However, soft excavation to be undertaken by hand labour, using hand tools, shall be further broken down by the introduction of an additional class of material, viz., soft excavation Class A, in accordance with the provisions of the project specification.
The total estimated quantity of excavation, as classified in terms of ……… is indicated in the Contract Prices. The tenderer may sub-divide this quantity into two components, viz., the quantity of material to be excavated by the use of powered, mechanical equipment and the quantity to be excavated by hand labour using hand tools.
One third (1/3) of every quantity of excavation to be undertaken by hand labour must be entered against the appropriate extra-over items provided in the Schedules for soft excavation Class A.
Should the tenderer fail to indicate a quantity of excavation to be undertaken by hand labour, notwithstanding that he would find it necessary to utilize hand labour, it will be assumed that all excavation, whether undertaken by machine, or by hand labour, is to be paid for at the rates tendered for machine excavation

The Contract Prices can reflect this mechanism as follows :

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT R C
3.1	Earthworks Excavate trenches in all materials, backfill and dispose of surplus material for stormwater pipes not exceeding 1,5 m deep (Total quantity 1 500 m³) to be allocated in items 3.1.1 and 3.1.2 below in accordance with Part 3 of the Conditions of Tender.				
3.1.1	Machine excavation	m³	.... *		
3.1.2	Hand excavation	m³	.... *		
3.1.3	Extra over 3.1.2 for hand excavation in soft class A. <u>(Quantity to be one third of quantity entered under 3.1.2)</u>	m³	.... *		
3.2	Extra over items 3.1.1 and 3.1.2 for :-				
	: Intermediate excavation	m³	250		
	: Hard rock excavation	m³	150		

* To be completed by the contractor.

G4 Encouraging contractors to implement employment-intensive road technologies

The labour intensiveness of roadworks is highly dependent upon the choice of technology and the cost of roadworks is, accordingly, sensitive to the choice of technology. If, however, the contractor is permitted to select the technology and contracts are awarded in terms of a development objective price mechanism, a balance between price and the attainment of socio-economic deliverables can be achieved.

A simple way to do this is to present contractors with a range of options which are acceptable to the employer and to permit contractors to tender and price what they see to be the most competitive options.

Contract Prices can reflect this mechanism as follows :

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT R C
1.1	**BASE** **Option A:** Construct base course with graded crushed stone from commercial sources **Option B:** Construct dry/-waterbound Macadam base course with stone imported from designated sources. Construct base course using Option . . . . (to be completed by contractor)	m2	2010		
ITEM NO	**DESCRIPTION**	**UNIT**	**QUANTITY**	**RATE**	**AMOUNT R C**
1.2	**PAVEMENT STRUCTURE** **Option A :** 150mm C4 subbase, 100mm G1 base, 20mm AC wearing course, complete **Option B :** 100mm C4 subbase, 100mm WM2 base, 20mm AC wearing course complete **Option C :** 100mm G7 subbase, 20mm bedding sand, 60mm type SA interlocking blocks complete Construct pavement using option . . . . (to be completed by contractor)	m2	2000		

The following clause should be inserted into the Conditions of Tender in order to cater for the different quantities which result from the different thicknesses of layerworks. This is important in the adjudication of tenders.

PAVEMENT STRUCTURES In order to meet the contract participation goal, the Contractor may select a pavement structure from the alternatives presented on the drawing. Each option or component thereof is scheduled separately in the Contract Prices. The Contractor must state in his tender under the relevant scheduled item which alternative his tender is based on. Contractors will be bound to the pavement structure so selected. The quantities scheduled in respect of earthworks are based on the pavement design with the greatest depth. Adjustments will be made by the engineer in the tendered price to reflect changes in earthworks costs arising from pavement selections prior to the awarding of points for price.