LOW COST ROAD SURFACING (LCS) PROJECT

LCS WORKING PAPER No 14

GRADING EQUIPMENT FOR EARTH & GRAVEL ROADS

by

Robert Petts, BSc, CEng, MICE, MIHT, MIAgrE,
Intech Associates

April 2003

THE LOW COST ROAD SURFACING INITIATIVE

The Low Cost Road Surfacing (LCS) initiative aims to provide documentation and international guidelines on the provision and maintenance of low cost road surfaces and basic access for rural communities in economically emerging and developing countries (EDCs). It is based on a research project funded principally by the British Department For International Development (DFID) under its Knowledge and Research (KaR) programme. The initiative is led by UK-based specialist consultants Intech Associates. Collaboration is being established with a number of organisations with interests or experience in the sector, including CSIR, TRL Ltd, ILO/ASIST Africa and Asia-Pacific, the ILO-SIDA funded Upstream Project and Ministry of Rural Development Cambodia, WSP International, Ministry of Transport Vietnam, Greater Mekong Sub-region Academic Research Network, The Institute of Technology of Cambodia, Chieng Mai University Thailand, the Committee C20 (Appropriate Development) of PIARC (World Road Association) and the International Focus Group. The LCS programme is being implemented over a 4 year period from 2001 to 2004.

The LCS programme is concerned with supporting sustainable improvements in low cost, road surfacing and basic access to support poverty reduction initiatives in rural communities. This implies the effective use of local resources, particularly human resources, locally available and alternative materials, and readily available and low cost intermediate equipment wherever possible. In the situation of scarce financial resources, it also requires the application of affordable and appropriate standards and adoption of techniques suitable for use by the indigenous private sector (particularly small domestic construction enterprises) and local communities. The application of good management practices coupled with adequate technical inputs are also encouraged.

It is intended that dissemination of the guidelines will be through electronic media as well as more traditional publication routes.

INTERNATIONAL FOCUS GROUP

TRL is currently carrying out a number of research projects on low volume sealed and unsealed roads for DFID and other Donors. Intech Associates is carrying out research on low cost surfacing with a number of partners. As part of these projects, an International Focus Group (IFG) has been established. The main function of the IFG is to thoroughly examine technical, economic and social issues arising from the project work. The group will also provide a focus to improve opportunities for dissemination of project results. The IFG being developed will comprise technical experts and engineers from a number of African, Asian and other countries as well as other international experts. Participation in the IFG will provide opportunities to:

- *build regional and international partnerships*
- *exchange ideas, experiences, information and data*
- *strengthen local knowledge with new information*
- *build on existing local research*
- *promote wider acceptance of the projects themselves*

Four projects listed below, are of particular interest to the IFG. Projects 1, 2 and 4 are part of the DFID's Knowledge and Research programme, whilst Project 3, is a collaborative research project involving a number of different donors:-

Project 1: Reducing Whole Life Costs: Environmentally Optimised Design
Project 2: Minimising the Cost of Sustainable Basic Rural Road Access
Project 3: Engineering Standards for Labour-based Roads
Project 4: Low Cost Road Surfacing

This document is intended to inform and provoke discussion, contributions and dissemination regarding surfacing aspects or rural roads. The LCS Project welcomes dialogue with engineers, managers, organizations, communities and individuals active or interested in the rural transport sector with the objective of the promotion of a sustainable rural access approach for EDCs.

This document is an output from a project funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of the DFID.

GRADING EQUIPMENT FOR EARTH AND GRAVEL ROADS

First Edition: January 2003
Second Edition April 2003

COPYRIGHT

© Intech Associates

Extracts from this publication may be reproduced provided the source is acknowledged as:-
"Intech Associates"

ACKNOWLEDGEMENTS

Material for this paper has been assembled from assignments and colleagues working in the appropriate technology roadworks sector in Africa, the Americas, Asia and the Pacific, as well as available reference documentation. Important cooperation from engineers and other personnel in the road authorities in these countries has been supported by a number of agencies and organisations including DFID, BPWA, CIDA, DANIDA, DGIS, EU, Helvetas, KfW, NORAD, SDC, SIDA, USAID, ILO/ASIST (Africa and Asia-Pacific), PIARC (World Road Association), TRL, UNDP, UNCDF and the World Bank. Cooperation has been particularly active from the ILO-SIDA Upstream Project and Ministry of Rural Development, Cambodia, and the WSP International - Ministry of Transport Vietnam - DFID - World Bank Rural Transport Project. The author wishes to acknowledge the cooperation and support received from these individuals and organisations, as well as the valuable contributions and comments on the drafts provided by colleagues.

THE AUTHOR

Robert Petts is the Principal of Intech Associates; Consulting Engineers to the road management and maintenance sector: e-mail: rob@intech-consult.demon.co.uk

Abbreviations

ASEAN – Association of South East Asian Nations
CAFEO – Conference of the ASEAN Federation of Engineering Organisations
CSIR – Council for Scientific & Industrial Research
DFID – Department For International Development
EDC - economically Emerging and Developing Country
GMSARN – Greater Mekong Sub-region Academic and Research Network
IFG – International Focus Group
IFRTD - International Forum for Rural Transport and Development
ILO/ASIST - International Labour Office/Advisory Support Information Services & Training programme
IMT – Intermediate Means of Transport
ITC – Institute of Technology of Cambodia
ILO – International Labour Organisation
KIHBT – Kenya Institute of Highway and Building Technology
KTC – Kisii Training Centre
LCS - Low Cost (Road) Surfacing
PRIP – Provincial and Rural Infrastructure Project
SEILA – a rural development programme named after the Khmer for foundation stone
TRL - Transport Research Laboratory
vpd - vehicles per day

EXECUTIVE SUMMARY

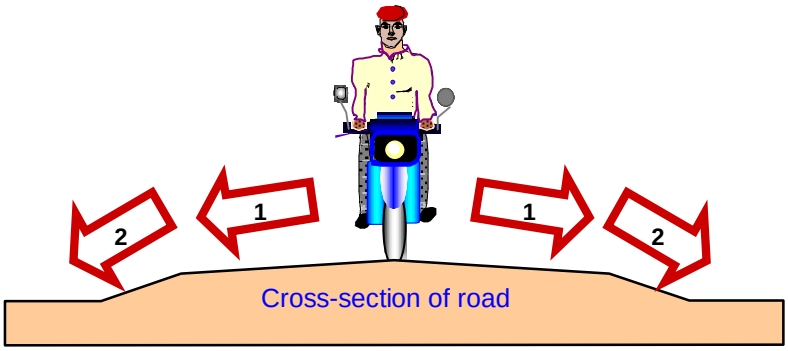
The equipment available on the international market for grading earth and gravel roads is generally expensive to purchase and operate. Many of the equipment models are designed for operation in a high-wage, low-capital-cost environment. For developing countries, the need to import, the costs of purchase, ownership and operation, and the nature of the grading work make this type of equipment impractical and/or too expensive for sustainable application on roads serving poor communities in a limited resource environment.

Unpaved (earth or gravel) roads will be the de facto surface type for access for countless poor communities for many years. This paper provides the rationale and a possible framework for the development of locally made, low cost grading equipment for use on low traffic volume unpaved roads serving poor communities, in South East Asia, Africa, the Americas and other economically Emerging and Developing Countries (EDCs).

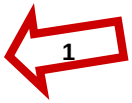
1. THE NEED TO REGULARLY GRADE AN EARTH OR GRAVEL ROAD

To maintain the condition of the surface of an earth or gravel road and to avoid serious deterioration, the camber or crossfall of the road surface needs to be regularly reshaped to shed rainwater to the roadside and the side drains/embankment edge for efficient disposal. Frequency of grading required is normally between once and four times per year.

WATER IS THE MAIN ENEMY OF ROADS



Drainage of an earth or gravel road to ensure year-round access must be achieved by 2 key features: -



maintaining cross fall (camber) to drain rain water off the road,

and

ensuring that rain water flows from the edge of the road surface (the shoulder) into side drains, or down the embankment slopes, and away from the road.

If these features do not exist now, then they should be provided as soon as possible, AND MAINTAINED.

A crossfall of 3 – 7% needs to be maintained at all times[1]. If 'grading' is not carried out regularly, the road surface will rapidly develop potholes and ruts due to the action of traffic and rain. Vehicle operating and transport costs will rise as a result. For gravel roads the result is accelerated gravel loss; increasing even further the already high maintenance burden of this type of surface (due to the regular need for periodic maintenance re-gravelling). Without regular grading, earth roads quickly become impassable to normal traffic in the rains.

Ungraded roads will eventually become very difficult to pass. Vehicle operating costs will be high. Ungraded roads can be impassable in the rains. Transport operators are reluctant to provide services on ungraded roads and will raise fares for goods and passengers to reflect the high operating costs.

Photographs: © Intech Associates

1 Low Cost Surfacing Project R7782, Guidelines for Gravel Surfaces.

2. GRADING REALITY - THIS ESSENTIAL MAINTENANCE TASK IS RARELY ACHIEVED ON RURAL ROADS in economically emerging and developing countries.

Grading is rarely achieved on a regular and effective basis in many EDCs for a range of reasons. The problem becomes extremely serious in countries in South East Asia, West Africa and Central America, which experience medium/high and intensive rainfall, and the common shortage of suitable gravel surfacing materials within short haulage distances. Lack of unpaved road grading seriously shortens the life of gravel surfaces and leaves most unpaved roads in a universal state of disrepair throughout the year.

Camber reshaping can be carried out by labour, however it is very difficult to achieve good and consistent results over an extended period of time, due to the management arrangements and funding/motivation required to organise the task on a regular basis. One problem is that the community or road users usually do not appreciate the problem until the camber has disappeared and serious surface deterioration is evident. By this stage major reshaping is required which needs mobilization of considerable resources.

For routes with high traffic, there are also safety issues of labour frequently working on the road surface. For such situations a low cost, locally made, equipment solution is particularly desirable.

3. WHY THE CONVENTIONAL EQUIPMENT APPROACHES DO NOT WORK

Conventional (imported) motor graders are too large, powerful, sophisticated and expensive[2] for maintenance of most rural roads in developing countries. They would cause more damage than benefit if used for maintenance grading of many tertiary roads[3]. These machines have increased in size and MAXIMUM power of 100hp (75kW) in the 1950s, to a MINIMUM power of about 150hp (110kW) now for the common manufacturers. This development reflects the needs and operational environment of the rich DEVELOPED countries (where operators wages are typically more than US$150 per day, and capital is relatively easy to access at low interest rates), and not those of developing countries. The experience of using these machines for road maintenance in developing countries has been almost universally expensive, problematic and unsustainable[4]. Use of imported, un-common, smaller motor graders and second hand equipment usually leads to problems with obtaining spares and achieving acceptable serviceability at reasonable cost.

The towed grader approach has been very successfully adopted in a number of countries, particularly in Eastern and Southern Africa. The towing machine is normally a standard two-axle agricultural tractor. Over 2,000 Arthur Garden towed graders have been produced in Zimbabwe over the last 50 years. The simplicity of design and maintenance mean that many of these models are still serviceable, and unit costs are low. A number of other towed graders rated between 1 and 5 tonnes are also manufactured in Kenya, South Africa and UK.

In South East Asia the availability of 2 axle agricultural tractors (especially in the higher power range of about 100hp required for the heavy towed graders) is currently low. Although the light (1 – 2 tonne) towed graders would be suitable for rural road grading in South East Asia, the costs of importation from Africa would be high. Towed drags, often fabricated from scrap material, are used in Africa to reduce corrugations on unpaved roads. However drags are not able to reshape the camber.

There is a need to develop a locally fabricated grading solution, or range of solutions, between the light equipment methods used in Africa and simple drags.

---

2 Caterpillar 120H – the smallest model in the range – costs about US$175,000 delivered.

3 Many rural roads are narrow (2 – 5metres) and these machines are simply too large to grade such roads.

4 Agricultural Tractors in Roadworks, MART Working Paper No 7, Robert Petts, 1996.

4. A NEW APPROACH IS REQUIRED

It is desirable to set up a system of PREVENTATIVE maintenance by moving relatively small amounts of material on a regular basis to re-form the road camber and keep it between 3 and 7% crossfall. The activity should be a ROUTINE operation. If this can be achieved using low cost, locally made equipment that can be operated by the community or local contractors, then a cost-effective solution may be achieved.

PLANNED and timely routine maintenance of the earth/gravel camber will minimise the deterioration of the road and help to prevent expensive rehabilitation works:-

"A stitch in time saves nine"

5. THE PROPOSED SOLUTION

A locally manufactured solution is required that will enable the maintenance grading of gravel and earth roads with both low initial capital and operating costs. For some provincial or secondary roads, adequate routine grading could be achieved with simple towed or self-propelled equipment using power of less than 50hp (37kW)[5]. Tertiary roads with established camber could be routine maintenance graded with smaller equipment towed by small vehicles/tractors or animals, or could be self-propelled.

Some examples of appropriate equipment exist in some other countries (see Sections 8, 9 and Annexes). However even these are sometimes not appropriate for the physical conditions and operating environment in many poor communities in South East Asia.

Considering the experiences and established practices in various regions and the valuable capacity to develop and manufacture intermediate equipment existing particularly in countries such as Cambodia and Vietnam, it is certainly feasible to develop a low-cost local solution in these and other countries. Three possible approaches are envisaged:-

Provincial or Secondary Roads

- A towed grader pulled for example by a 4/5 tonne truck or about 50hp (37kW) agricultural tractor
- A self-propelled grading machine utilising a low cost (e.g. Chinese) engine

Tertiary Roads

- A light vehicle/animal drawn grader or adjustable drag.

It is envisaged that local production models could be produced for between US$200 – 8,000 each, depending on the complexity of the equipment. If an adjustable light grader could be developed to meet all of these requirements, the owner would have greater opportunities for making the investment pay.

It is important to appreciate that such equipment would not be appropriate for roads that had 'lost' their camber, but that the light equipment would be sufficient for planned routine light grading only. The application of such equipment would need to be an integral component of a properly planned, resourced and managed unpaved road network asset management system. The need for other solutions for heavy or rehabilitation grading are a separate consideration.

5 At altitude up to about 1,000metres and depending on material type. About 50 years ago, standard motor graders were of the power range 50 – 75hp.

6. PERFORMANCE AND ASSESSMENT

Each model will have to be capable of cutting into the existing road surface to a depth of between O and 2 - 5cm over approximately 1 - 1.5metre width at the edge of the road with one pass. By angling the blade or cutting edge(s), the pass should also draw the loosened material towards the centre of the road, spreading it evenly. Hard soils or gravel surfaces may need to be scarified with a preliminary pass using separate tines to loosen the road surface.

Grading to re-form the camber

Cut – maximum about 10cm in a number of passes

Fill and distribute

For a completely flat existing road surface, two or more cutting passes may be required to dig the material to restore the camber completely. Each pass would cut up to 5cm to a maximum total depth of about 10cm.

Further passes may be required to spread material back towards the edge of the road and discharge excess material[6].

A crossfall of about 7% should be achieved with the loose material of the reshaped camber prior to compaction or consolidation.

Prototype performance assessment should include the following observations and assessments regarding ability to re-grade existing earth and gravel/laterite surfaces:-

- Number of passes to create 5% and 7% camber (before the follow on compaction), from both an existing level surface and a typically deteriorated road surface in various types of material,
- Maximum depth of cut on a level surface at 7% crossfall angle,
- Surface material properties and condition (e.g. gravel/sandy/clay, particle size grading, moisture content, DCP[7])
- Speed of operation,
- Estimated initial cost of production and retail price,
- Estimated operating cost over an economic life,
- Estimated unit costs of grading (per km of specified width of road),
- Potential physical weaknesses and constraints,
- Observations on safety and operation,
- Views of potential production enterprises,
- Views of community, operator and contractor representatives,
- Recommendations regarding commercialization,
- Recommendations regarding operational arrangements.

6 For grading techniques, refer to the PIARC International Road Maintenance Handbook.

7 CBR measurement by Dynamic Cone Penetrometer.

7. APPLICATION AND BENEFITS

Contract grading could be developed as a low-cost service for more important roads. For lower category roads reshaping could be carried out by community organisations or small local contractors. This would be achieved at a fraction of the cost of grading using heavy equipment or large, city based, contracting organisations. There would also be export potential for successful equipment manufacturers.

It is proposed to develop locally manufactured solutions for the Cambodian and Vietnamese grading needs under the SEILA, PRIP and other rural roads projects.

The benefits would be:-

- Low cost grading supports labour-based maintenance of the road shoulders, earthworks and drainage system; making maintenance more manageable,
- Earth and gravel/laterite roads maintained at low cost to the community/government,
- Preservation of expensive infrastructure investments, which would otherwise rapidly deteriorate to a condition requiring expensive rehabilitation,
- Improved access for rural communities,
- Reduce transport costs for rural communities,
- Development of local manufacturing capability and employment,
- Development of small local enterprises to provide grading services and employment,

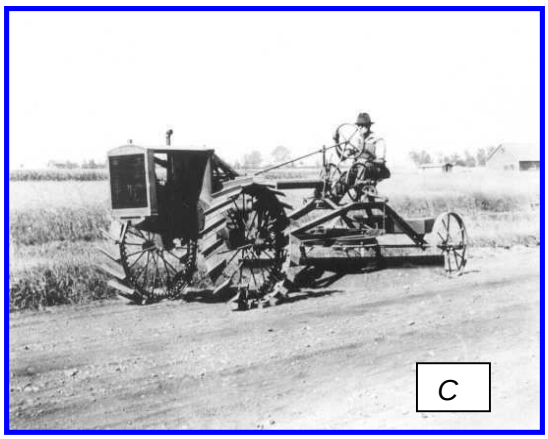
These benefits will help to reduce rural poverty.

8. SOME PROVEN GRADING AND DRAGGING SOLUTIONS

A – Expensive and problematic Motorgrader. Designed for rich country conditions. Principally used for construction purposes. From 150hp upwards. Cost from about US$175,000 new.

B – Heavy Towed Grader. 5 tonne, requires 100hp 4wd agricultural tractor to tow it. In production in Kenya. Cost of tractor and towed grader about US$70,000 (US$40,000 + US$30,000).

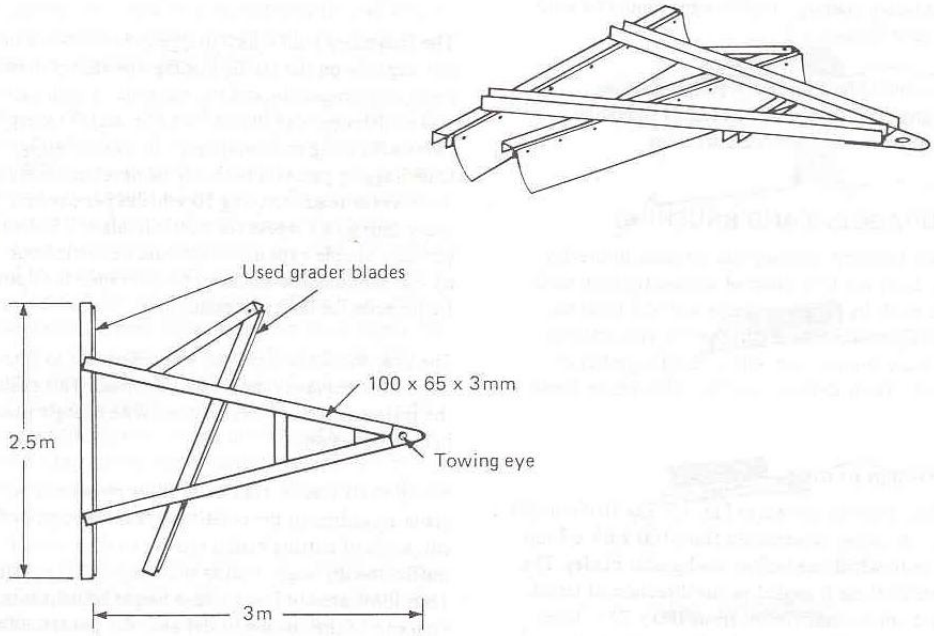
C – Early light motorgrader.



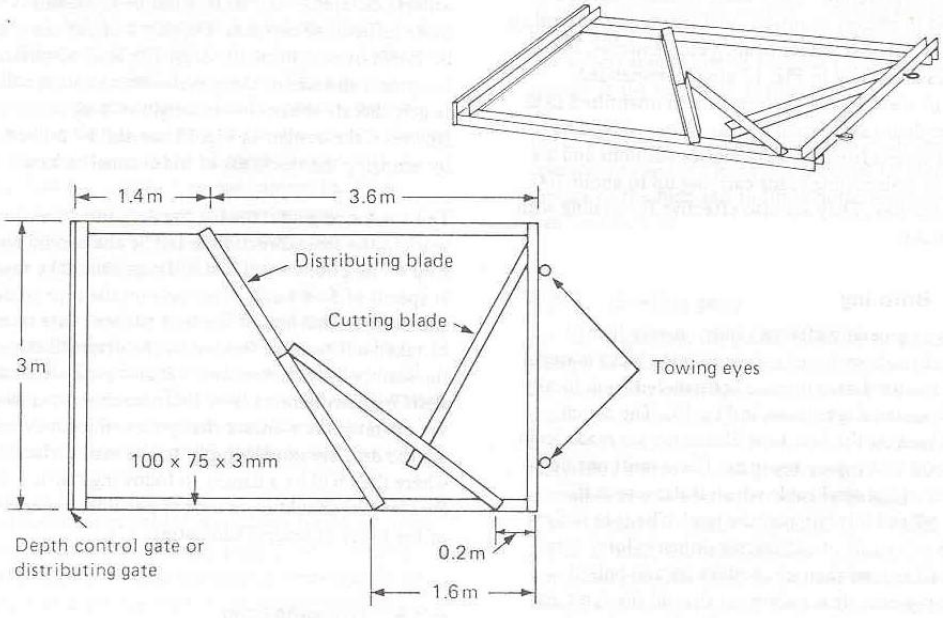
D – Light (2tonne) towed grader, currently in production in Zimbabwe (over 2,000 produced in the last 50 years). Grader cost ex-works approximately US$9,000. Requires 40hp tractor for towing (approximately US$20,000).

Photographs: © Intech Associates

E – Towed Drags – source TRL Overseas Road Note 2



(a) 'A' - FRAME DRAG UTILISING GRADER BLADES



(b) RECTANGULAR TRIPLE BLADED DRAG

Fig. 12 Metal cutting drags

.

9. REVIEW OF AVAILABLE GRADING EQUIPMENT

The Annexes contain details of brochures of some of the intermediate equipment currently available from various countries. They are summarised in the following table.

MAKE	DESCRIPTION[8]	COUNTRY OF ORIGIN	APPROXIMATE COST EX-WORKS
Motorgrader - VARIOUS	Self propelled motor grader, power usually 150hp+	USA, Japan, Germany etc.	US$150,000+
Turbograde 5000	Made by CMC Motors, 5tonne, requires 100hp 4WD towing tractor	Kenya	US$30,000
Simba	3.5 tonne, may be surcharged, requires 100hp 4WD towing tractor	UK	US$30,000
Arthur Garden	2 tonne mechanical, based on original Gallion design, requires 40hp 2WD towing tractor	Zimbabwe	US$ 9,000
Barland Knight	2 tonne mechanical, based on original Gallion design, requires 40hp 2WD towing tractor	South Africa	To be confirmed
Barland Agrigrader	1.5 tonne hydraulic, requires 50hp 2WD towing tractor	South Africa	To be confirmed
Barland Universal	1.5 – 2.0 tonne hydraulic, requires 50hp 2WD towing tractor	South Africa	To be confirmed
Barland Unigrader	1.0 tonne hydraulic, requires 40hp 2WD towing tractor	South Africa	To be confirmed
Towed Drag	Simply reduces corrugations – does not reshape the camber, can be fabricated from scrap materials	Various	From about US$100

10. CONCLUSIONS

The foregoing discussion provides the rationale and basis for developing locally fabricated grading equipment for rural roads, particularly in South East Asia, Africa and Central America. It is evident that the development and mainstreaming of the equipment will require the cooperation of a range of skills including mechanical design and production, road works, economics, community involvement and business development. The potential benefits are substantial in contributing to the improved access and transport services for the rural poor in South East Asia and elsewhere.

8 At altitude of more than 1,000m the rated power requirements may be higher.

References

1. Road Maintenance - Options for Improvement, G. A. Edmonds and J. J. de Veen, ILO, 1982.

2. Technology Development in Road Construction and Maintenance for Developing Countries, paper for the conference on Science and Technology in Third World Development, University of Strathclyde, R. C. Petts, 1993.

3. The State of the Art - The Global View, paper for the Conference on Opportunities for Labour Intensive Roadworks, University of Hertfordshire, R. C. Petts, 1995.

4. Road Deterioration in Developing Countries, Causes and Remedies, A World Bank Policy Study, 1988.

5. The Road Maintenance Initiative, Road Maintenance Policy Seminars documentation, Sub-Saharan Africa Transport Program, The World Bank and the Economic Commission for Africa, 1989.

6. Rural Roads in Sub-Saharan Africa. Lessons from World Bank Experience, J. Riverson, J Gaviria and S. Thriscutt, World Bank, 1991.

7. Management and Financing of Roads, An Agenda for Reform, Ian G. Heggie, World Bank Technical Paper Number 275, Africa technical Series, 1995.

8. Proceedings of the Highway Policy Seminar for Countries of the Former Soviet Union, Moscow, May 15-19 1995, World Bank, EU, GTZ and Federal Highway Department of the Russian Federation.

9. Roads, a new approach for Road Network Management and Conservation, United Nations Economic Commission for Latin America and the Caribbean, June 1993.

10. Technology Choice for the Construction and Maintenance of Roads in Developing Counties, Development and Guidelines, G. A. Edmonds and J. J. de Veen, ILO Geneva, 1991.

11. The Problems facing Labor-based Road Programs and What to Do About Them: Evidence from Ghana, E. A. Stock for World Bank, 1996.

12. Transformation of the Labour Construction Unit from an Executing to a Contract Supervisory Agency, A. T. Lehobo for MART/ILO, 1995.

13. Promoting small contractors in Lesotho: Privatization in practice, Proceedings of the Institution of Civil Engineers, D. W. J. Miles, 1996.

14. Road Deterioration in Developing Countries, Causes and Remedies, A World Bank Policy Study, 1988.

15. Expanding Labor-based Methods for Road Works in Africa, World Bank Technical Paper No 347, E. A. Stock and J. J. de Veen, 1996.

16. Intermediate Equipment to support Labour-based Roadworks: Development, Testing and Evaluation of Prototype Equipment, ILO Seminar Proceedings, Harare, R. C. Petts, 1993.

17. Towed Graders and Tractor-Based Maintenance of Low-Volume Roads, 5th International Conference on Low-Volume Roads, TRB, R. C. Petts and Dr T. E. Jones, 1991.

18. Roads 2000 - A Programme for Labour and Tractor Based Maintenance of the Classified Road Network, Pilot Project Final Report, Intech Associates for MoPWH, Kenya, 1993 (unpublished).

19. International Road Maintenance Handbook, R. C. Petts for TRL, ODA and PIARC, 1994.

20. European Construction Costs Handbook, Spon's, Davis, Langdon and Everest, First Edition, 1992.

21. Yearbook of Labour Statistics, ILO Geneva, 1994.

22. MART Working Paper No 1 - Towards Guidelines for Labour Based Contracting, a Framework Document, edited by D. Miles,1996.

23. MART Working Paper No 5 - Intermediate Equipment for Labour-Based Roadworks, Workshop Report, P. Larcher, D. Miles and R. C. Petts, 1996.

24. A study of the cost-effectiveness of grading unpaved roads in developing countries, Research Report No 91, T. E. Jones & R. Robinson, Transport and Road Research Laboratory, 1986.

25. MART Working Paper No 2 - The use of Intermediate Equipment for Labour Based Roadworks: A review of the current situation, 1997.

26. Caterpillar Performance Handbook, Various editions, Caterpillar Inc.

27. Choosing and Using Farm Machines, Land Technology Ltd, Prof. B. D. Witney, 1995.

28. Management of Construction Equipment, Second Edition, Prof. F. Harris & Prof. R McCaffer, 1991.

29. Spon's Plant and Equipment Price Guide with updates to May 1996, Plant Assessment (London) Ltd and E Map.

30. MART Working Paper No 7 – Agricultural Tractors in Roadworks, Robert Petts, 1996.

31. Guidelines for the development of Small Scale Tractor-based Enterprises in the Rural and Transport Sectors, for DFID, W Hancox, & R C Petts, 1999.

32. A tractor and labour based routine maintenance system for rural roads, Kingstone Gongera and Robert Petts, Institution of Agricultural Engineers, Landwards, 2000 & IRF 2001.

33. Improving Local Resource Utilisation in Roadworks in Developing and Emerging Countries, Dr C Gourley, Dr T Toole & R C Petts, IRF 2001.

34. Rationale for the Compilation of International Guidelines for Low-Cost Sustainable Road Surfacing (LCS) Working Paper No1, R C Petts, 2001.

35. Paving The Way For Rural Development & Poverty Reduction, Dr Colin Gourley (TRL), Anthony Greening (TRL), Dr David Jones (CSIR), and Robert Petts (Intech) Phnom Penh, CAFEO, 2002.

36. MART Intermediate Equipment Handbook, R C Petts, 1999.

37. Manufacturers Brochures

38. Overseas Road Note 1, Maintenance Management for District Engineers, TRL, 2nd edition, 1987.

39. Overseas Road Note 2, Maintenance Techniques for District Engineers, TRL, 2nd edition, 1985.

ANNEXES

INTERMEDIATE GRADING EQUIPMENT AVAILABLE ON THE INTERNATIONAL MARKET

5 tonne heavy towed grader, CMC Motors, made in Kenya

3.5 tonne towed grader, Simba, UK

Photographs: © Intech Associates

HEAVY TOWED GRADER (5 TONNE) **NO. REQUIRED:**

SPECIFICATION	RECOMMENDED	SUPPLIER/TENDERER OFFER
1. General Heavy duty, single axle, towed grader for construction, reconstruction and maintenance of camber on earth or gravel roads, construction or maintenance of turn-out (mitre) drains. Complete with heavy duty scarifier to loosen hard compacted material		
2. Towing Equipment required	Wheeled agricultural tractor, 4 wheel drive, Min 100 HP (75kW) DIN	
3. Dimensions a) Max Overall Length b) Max Overall Width	 6,500 mm (ex-scarifier) 2,500 mm (with blade stowed for travel)	
4. Construction Heavy duty, welded steel. Main frame of 254 mm Min Rolled Steel Channels. Turntable on "A" frame with hydraulically operated height and sideshift control. Greased wear - adjustable ball (80 mm Min) and socket joint connection of "A" frame apex to main frame. Turntable lockable in range of positions. Rear mounted, hydraulically operated scarifier. Operator control platform behind and in full view of blade		
5. Weights a) Gross Weight b) At hitch (static)	 Min 5,000 kg Max 6,500 kg Min 1,500 kg, Max 3,000 kg	
6. Axle Heavy duty stub axles each 5,000 kg Min load rating. Stub axles welded in position. 8 No high tensile steel studs		
7. Wheels 8" (200 mm) rims. Rated load Min 5,000 kg.		
8. Tyres	1000 - 20, 14 PR	
9. Reflectors	Front and rear	

HEAVY TOWED GRADER (5 TONNE) (CONT)

SPECIFICATION	RECOMMENDED	SUPPLIER/TENDERER OFFER
10. Towing Eye Heavy duty swivel hitch with towing eye, welded or bolted to chassis, fitted for 450 mm hitch towing height	BS 5891 (1980) or ISO 5692 (1979) Inside hole dia. 50 mm Swivel barrel 76 mm dia. shaft into bush bearing	
11. Parking Stand Fold back/adjustable heavy duty parking stand for 450 mm height of towing eye		
12. Mouldboard length	3,600mm (12') nominal 3,000mm (10') option	
13. Mouldboard depth	500 mm nominal	
14. Mouldboard thickness	18 mm Min	
15. Mouldboard pitch	6 positions, manual adjustment	
16. Mouldboard positions	Min 6 left, 6 right, hydraulic locking device. Turntable turning angle from centre position ±55º Min	
17. Turntable Diameter	1,200 mm approx	
18. Cutting Edges	Standard Caterpillar / Komatsu specifications and end overlays	
19. Hydraulics Main lift rams (2 No) Side shift rams Turntable Lock Ram Scarifier Ram	 Stroke 700 mm Bore 80 mm Stroke 700 mm Bore 80 mm Stroke 100 mm Bore 50 mm Stroke 400 mm Bore 100 mm	
20. Working pressure	Minimum 1,500 psi Maximum 2,250 psi	
21. Controls on grader	5 element spool valve	

HEAVY TOWED GRADER (5 TONNE) (CONT)

SPECIFICATION	RECOMMENDED	SUPPLIER/TENDERER OFFER
22. Hydraulic lines to tractor	One delivery One return	
23. Hoses	Quick release coupling type ½" (13 mm). Dummy couplings for disengaged situation	
24. Oil Supply assumed	60 litres/min Minimum	
25. Safety	Heavy duty roll bar and overhead sun/rain protection	
26. Jacking Points	At hitch and at each side of the grader close to stub axles	
27. Recommended Service Kit Spares	4 sets of ram seals, 1 set of hydraulic hoses and couplings, 6 sets of cutting edges, 2 sets of end overlays, 1 set of nuts and bolts for the above	
28. Scarifier	Hydraulically operated with 5 replaceable tines and replaceable tips. Penetration 400mm Min	
29. Miscellaneous - Spare wheel and lockable carrier mounted on body - Tool Kit in lockable box - Operation, Service and Spare Parts Manuals - Spares as specified Full corrosion protection, finish in yellow paintwork		
SUPPLIER/TENDERER'S SPECIFICATION MAKE: MODEL: COUNTRY OF ORIGIN :		

Recommended Specification for
2 tonne Mechanical Towed Grader
(Operating Weight : 2 tonnes approx)

A. EQUIPMENT BASIC SPECIFICATION
(All functions are manually / mechanically operated)

MASS, WITHOUT SCARIFIER:	
Total mass	1,880 kg
On Front Wheels	900 kg
On Rear Wheels	980 kg
DIMENSIONS:	
Length overall	6,375 mm
Width overall	2,260 mm
Height overall	2,209 mm
Wheel base	4,267 mm
MOLDBOARD AND BLADE:	
Blade length	2,743 mm
Moldboard, with end boots	2,743 x 406 x 12.7 mm
Pitch positions	3
Side shift positions, left or right	2
Side shift left or right	152 mm
Blade positions left or right	8
Cutting depth	114 mm
GENERAL:	
Blade reach outside rear wheel (frame in side shift position)	838 mm
Ground clearance when travelling	381 mm
Angle when ditch cutting	25°
Ditch cutting depth	432 mm
Maximum blade bank reach	1,651 mm
AXLE FRONT:	
Single channel section	203 x 76 mm
Track	1,327 mm
Tyres	750 x 16 x 8 ply
Ground clearance	394 mm
AXLE REAR:	
Box section	102 x 127 mm
Track	2,006 mm
Tyres	750 x 16 x 8 ply
Ground clearance	419 mm
Side shift, right or left	381 mm
SCARIFIER REAR MOUNTED:	
Mass	298 kg
Width of swath	463 mm
Teeth (with replaceable tips) number	3
Depth of cut	127 mm
Box section	150 x 125 mm
Ground clearance	220 mm

B. RECOMMENDED DELIVERY SPECIFICATION

1 A.G. 4000 complete with Scarifier mechanism as described in **A.**
1 Set cutting edges fitted to machine
1 Spare wheel fitted to machine
1 Set Scarifier shanks fitted to machine
1 Set Scarifier tips fitted to machine
1 Sun roof fitted with canvas cover
1 Towing eye attachment for single axle operation complete with 50 mm internal diameter towing eye to BS 5891 (1980) or similar and swivel barrel seating (This allows the front axle to be removed and mainframe coupling directly onto the tractor hitch with significantly increased load transfer to the tractor rear axle). If the towing tractor is fitted with a fixed hitch, then an adjustable parking stand will need to be fitted to the front of the towed grader mainframe.
1 Set plough bolts
1 Set safety chains
6 Reflectors: rear (2) side (2) front (2)
1 Wheel spanner
1 Heavy duty grease gun
1 Set main bolt spanners
2 Allen keys

Operator's / Service / Spares manual } Tool kit

C. RECOMMENDED OPERATING SPARES **FOR 2000 HOURS APPROX.** (Depends on Soil Conditions)

12 Sets of cutting edges
12 Sets of plough bolts
2 Sets of scarifier shanks
6 Sets of scarifier tips
2 Springs
6 Circle shoes
4 Sets end bits L/H & R/H
1 Set gear box bearings (back up)
2 Sets wheel bearings (back up)
2 Worm shafts L/H & R/H (back up)
2 Worm wheels L/H & R/H (back up)
12 lift arm spacers
24 Shear pins
1 Spare tyre 750 x 16 x 8 ply
1 Spare tube 750 x 16

NOTES:

1. The towed grader may be surcharged to increase operating weight. Please consult the manufacturer.

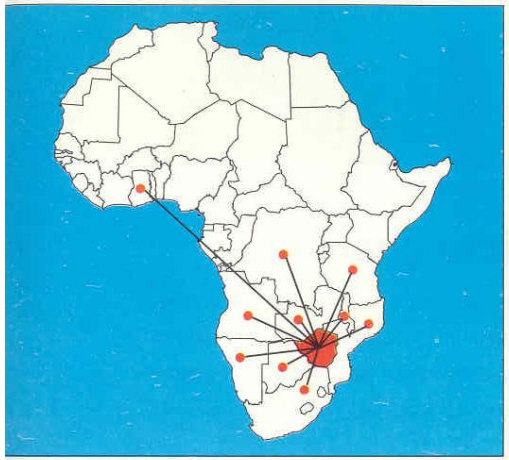
2. Minimum recommended specification for towing tractor:

   - ❑ 50 hp (38 kW) 2 wheel drive.
   - ❑ Heavy duty drawbar or pickup hitch.
   - ❑ Rear wheel weights if used in dual axle configuration.

MANUFACTURER'S ADDRESS:

Arthur Garden Engineering
Galion House, Douglas & Dumphries Roads, Heavy Industrial Sites, Harare, Zimbabwe.
Tel: Int + 263 4 754272 Fax: Int + 263 4 754274 E-mail: ag@zsr.com

MANUFACTURED FOR OVER 50 YEARS TRIED AND TESTED - AND DISTRIBUTED IN OVER 10 COUNTRIES IN AFRICA



• SOUTH AFRICA • BOTSWANA • MOZAMBIQUE • MALAWI • ZAMBIA • TANZANIA • ANGOLA • GHANA • NAMIBIA • ZAIRE

MANUFACTURERS AND DISTRIBUTORS OF:

- AG 4000 - 2000 TOWED GRADERS
- SPECIAL GRADER BLADE SECTIONS
- STANDARD GRADER BLADES
- A.G. MATERIAL HANDLING AND EQUIPMENT FOR AGRICULTURE, MINING, TRANSPORT & FOOD INDUSTRIES
- DONALDSON FILTERS AND AIR POLLUTION CONTROL SYSTEMS
- AMMAN DUROMAT COMPACTION EQUIPMENT

ENGINEERING DISCIPLINES

- MACHINISTS - FABRICATORS - DESIGNERS - PIPE WORK
- PROJECT MANAGEMENT

Specifications

MASS, WITHOUT SCARIFIER:	
Total mass	1 880 kg
On Front Wheels	900 kg
On Rear Wheels	980 kg
DIMENSIONS:	
Length overall	6 375 mm
Width overall	2 260 mm
Height overall	2 209 mm
Wheel base	4 267 mm
MOLDBOARD AND BLADE:	
Blade length	2 743 mm
Moldboard, with end boots	2 743 x 406 x 12,7 mm
Pitch positions	3
Side shift positions, left or right	2
Side shift left or right	152 mm
Blade positions left or right	8
Cutting depth	114 mm
GENERAL:	
Blade reach outside rear wheel (frame in side shift position)	838 mm
Ground clearance when travelling	381 mm
Ground clearance with moldboard 90° to machine	432 mm
Angle when ditch cutting	25°
Ditch cutting depth	432 mm
Maximum blade bank reach	1 651 mm
AXLE FRONT:	
Single channel section	203 x 76 mm
Track	1 327 mm
Tyres	750 x 16 x 6 ply
Ground clearance	394 mm
AXLE REAR:	
Box section	102 x 127 mm
Track	2 006 mm
Tyres	750 x 16 x 6 ply
Ground clearance	419 mm
Side shift, right or left	381 mm

AVAILABLE EQUIPMENT (EXTRA COST)

SCARIFIER 'V' TYPE: OR REAR MOUNTED:	
Mass	298 kg
Width of swath	463 mm
Teeth (with replaceable tips) number	3
Depth of cut	127 mm
Box section	165 x 114 mm
Ground clearance with shanks and tips	114 mm
Ground clearance with shanks only	165 mm
Ground clearance without shanks and tips	381 mm

SPECIFICATIONS, MATERIALS AND DESIGN SUBJECT TO CHANGE WITHOUT NOTICE

ARTHUR GARDEN ENGINEERING ZIMBABWE

HEAD OFFICE: GALION HOUSE, DOUGLAS & DUMFRIES ROADS, HEAVY INDUSTRIAL SITES, HARARE. TELEPHONE: 263-4-754272, 754164, 755465/6/7
HARARE, ZIMBABWE. P.O. BOX 2342. TELEGRAMS: "JEFLION", TELEX: 24274 ZW. FAX: 754274

AG 4000 towed grader

MANUFACTURED IN ZIMBABWE

REBUILDING ROADS

AIR STRIP MAINTENANCE

FIRE BREAKS

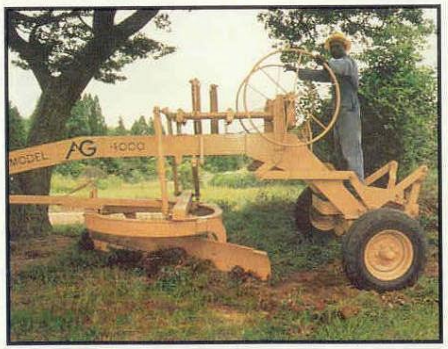
A cost effective and versatile mechanical grader

The A.G. 4000 is a sturdy and robust pull-type grader suitable for use with 30-45 kW tractors. A low line of draft ensures that more material is moved with the least tractive effort. Its wide moldboard has a replaceable cutting edge and all controls are simple and easy to operate from the operator's platform. The A.G. 4000 is also available with a heavy duty scarifier. This easy to use pull-type grader makes road building and levelling simple and easy. Ditching, sloping and scarifying are a few of its additional advantages. It is ideal for bush clearing and firebreak cutting as well as for maintaining and repairing rural roads.

Low cost road maintenance

CAMBERING

CONTOURING



SCARIFYING

KNIGHT

All purpose pull type grader

BARLAND

KNIGHT

Pull-type grader

- Versatile, easy to operate, tough and rugged construction.
- A proven record of operational reliability and performance under all normal working conditions.
- Big machine output, low cost operation.

Roadbuilding, grading, land levelling, bush clearance, ditching, sloping, firebreak cutting. The Knight all purpose pull type grader is suited to use with wheel tractors in excess of 35kW. It is built to operate in tough conditions with the minimum of maintenance.

The Knight can boast a carefree, no-nonsense simple mechanical linkage and control system designed to keep working year in and year out. It does not require a costly service routine to ensure it is maintained in proper operating condition. And most important, it is easy to operate with simple and convenient controls. A low line of draft allows more material to be moved with the least tractive effort. The wide mouldboard has a replaceable cutting edge. This easy to use pull-type grader makes road building and levelling simple and easy. Ideal for firebreak cutting and bush clearing as well as for maintaining and repairing country roads.

Mass

Total mass	1 850 kg
On Front Wheels	884 kg
On Rear Wheels	966 kg

Dimensions

Length overall	6 375 mm
Width overall	2 260 mm
Height overall	2 209 mm
Wheel base	4 267 mm

Mouldboard and blade

Blade length	2 743 mm
Mouldboard, with end boots	2 743 x 406 x 12,7 mm
Pitch positions	3
Side shift positions, left or right	2
Side shift left or right	152 mm
Blade positions left or right	8
Cutting depth	114 mm

Specifications subject to change without notice.

General

Blade reach outside rear wheel (Frame in side shift position)	838 mm
Ground clearance when travelling	381 mm
Ground clearance with mouldboard 90° to machine	432 mm
Angle when ditch cutting	25°
Ditch cutting depth	432 mm
Maximum blade bank reach	1 651 mm

Axle, front

Single channel section	203 x 76 mm
Tread	1 327 mm
Tyres	750 x 16 x 6 ply
Ground clearance	394 mm

Axle, rear

Box section	102 x 127 mm
Tread	2 006 mm
Tyres	750 x 16 x 6 ply
Ground clearance	419 mm
Side shift, left or right	381 mm

BARLAND

Member of the Barlow Rand group

BARLAND INDUSTRIAL EQUIPMENT CO.

59 Graniet Road Jet Park Ext 3 Boksburg 1460 Rep. of South Africa
Tel (011) 826-1526/7/8 Telex 7-49840 SA Telefax (011) 823-2201
P.O. Box 13742 Witfield 1467

AGRIGRADER

The low-cost, easy-to-operate combination of grader and multipurpose agricultural machine

BARLAND

AGRIGRADER

A modern, ruggedly engineered tractor-towed design proving its worth and reliability all over South Africa.

Applications include

- Farm-road maintenance
- Construction of new roads
- Preparation and maintenance of firebreaks
- Building and maintaining contours
- Land levelling
- Ditch digging
- Cutting furrows
- Irrigation earth-works

Gradeability ...

The Agrigrader is more than able to cope with the toughest grading conditions.
The design and angle of the blade, coupled with a weighted blade box - part of the machine and not a separate unit - and ballast-filled wheel arms ensure blade penetration even on the toughest road surfaces.

Simple ...

The Agrigrader was designed by road construction engineers to be operated by one man from the seat of his tractor. The controls are simple and straight-forward - a driver will not have to spend hours learning how to operate them to get the best out of the Agrigrader.

Versatile ...

The Agrigrader can be operated offset from the tractor's line of travel for grading under trees or close to fences. The grader can be offset without any time-wasting by removing a securing pin, positioning the wheel arms at the required angle of offset (left or right), and re-inserting the pin.

Unique ....

The design of the Agrigrader is unique. Blade lift and tilt is hydraulic to give the instantaneous and precise blade control necessary for really accurate grading. The angles of the blade can be adjusted quickly and easily by the tractor driver while seated by means of a mechanical blade-locking device that offers a variety of angles. The Agrigrader couples directly to the tractor's external hydraulic system by means of hoses fitted with quick-release couplings.

Built To Last ...

The Agrigrader is built to work and to last. Its blade is 20mm thick and made from wear-resistant Benox steel - usually reserved for costly motor graders. The cutting edges, scarifier shanks and tips of the Agrigrader are all standard motor grader components. The main frame is super-sturdy, built from 150mm by 100mm rectangular steel tubing with a wall thickness of 10mm. The reinforcing overlays on the upper and lower frame give the Agrigrader all the strength it needs and more for use behind the biggest tractors. The taper-roller wheel bearings are large and dust sealed, and all blade and wheel-arm pivots are fitted with long life Vesconite bushes.

Agrigrader Options

Standard Agrigrader - loss control valve
For use with tractors already fitted with two-spool hydraulic controls. Coupling to the tractor is by means of four hoses fitted with male quick-release couplings.

Agrigrader complete with two-spool control valve
Coupling to the tractors is by means of two hoses fitted with male quick-release couplings. There is provision for mounting the control valve on the tractor.

Agrigrader with five-shank scarifier complete with three-spool control valve
Coupling to the tractor is by means of two hoses fitted with male quick-release couplings. Provision has been made for mounting the control valve on the tractor.

Agrigrader Specifications

Blade width	3 048 mm
Blade cutting angles	90°-80°-70°-60°
Scarifier width	1 070 mm
Scarifier shanks	5
Off-set operating angles	11°-22°
Mass	1 500 kg
Transport length	5 550 mm
Transport width	2 400 mm
Recommended tractor power	40 kW and greater
Tractor hydraulic requirements	Pressure and return quick-release couplers from tractor's standard hydraulic system

Specifications are subject to change without notice

BARLAND

Member of the Barlow Rand group

BARLAND INDUSTRIAL EQUIPMENT CO.

Electron Avenue Extension, Isando 1600
PO Box 11 Isando 1600
Fax: (011) 929-0011
Tel: (011) 929-0111


UNIVERSAL
Multi-purpose Hydraulic Grader
BARLAND

UNIVERSAL

Power where you want it

The Universal grader is a hydrualically operated towed machine that can perform conventional grading operations with a standard agricultural tractor. It is actuated from the tractor's hydraulic pump and connected by means of quick release couplings. The grader has power where it is most needed - well over 1,5t mass at the cutting edge - and a big 600 mm high by 3048 mm wide blade which can be angled 50 degrees left or right.

Control

Being hydraulically operated the Universal grader is very responsive to operator control. The five valve control bank provides blade lift and lower at each end, blade angling, steering at rear wheels and scarifier control. Adjustment or correction on the move is immediate and fatigueless and provides a high degree of machine/operator productivity. The Universal is steerable at the rear wheels and is only partially dependent on the tractor for direction. The towing tractor is able to move in a constant direction while the grader operator is free to swing left or right, avoiding obstructions and working close to fences or under over-hanging branches. Side thrust can be balanced instantly by steering into the cut, a control measure similar to the lean wheel effect of conventional motor graders.

Maintenance

The Universal grader is extremely robust and has very few moving parts, resulting in long life and minimal maintenance costs.
Maintenance is confined to regular checking of tyre pressures, wheel nuts and greasing of moving parts.

Application

- Haul road maintenance and cutting of access roads for the forestry, mining and construction industries.
- District road and shoulder maintenance for Provincial and Local authorities.
- Road maintenance, contours, land levelling and cutting of firebreaks for agricultural operations.

Hydraulic Data

Min operating pressure	12 MPA
Min recommended flow	15 l/min

Control valve - 5 spool manually operated spring return, open centre with adjustable internal pressure relief. Closed centre facility also available.

Wheels and Tyres

Wheels	750 x 16 5 Stud
Tyres	6 ply Rib with tube
Axles	Stub axle with hub on taper roller bearings

General

Operator seat fully upholstered with slide restraints and suspension. Main frame fabricated from 43c cold rolled sections. All pin joints fitted with vesconite bushes.

Optional Extras

Seat Belts
Tractor mounted controls

Basic Dimensions

Overall length - Blade 45°	5 960 mm
Overall width - blade 90°	3 048 mm
Transport width - blade 50°	2 300 mm
Overall height - blade lowered	1 370 mm
Wheel track max	2 120 mm
Wheel track min	1 700 mm
MASS (including 300 kg ballast)	1 950 kg

Performance Data

Max cutting width	3 048 mm
Min cutting width	2 300 mm
Cutting depth	100 mm
Scarifying width	1 100 mm
Scarifying depth max	355 mm

Machine Data

Blade angling	50° each direction
Steering	25° each direction
Blade lift	370 mm
Blade depth	600 mm
Cutting edges (2)	1 524 x 203 Motorgrader STD
Scarifier tips and shanks (5)	Motorgrader STD

Specification subject to change without notice.

BARLAND

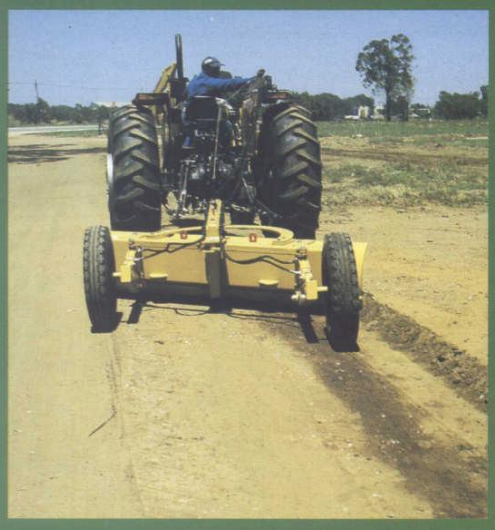
Member of the Barlow Rand group

BARLAND INDUSTRIAL EQUIPMENT CO.

Electron Avenue Extension, Isando 1600
PO Box 11 Isando 1600
Fax: (011) 929-0011
Tel: (011) 929-0111

UNIGRADER

Complete with two spool control valve.
Coupling to the tractor is by means of two hoses fitted with male quick-release couplings. Provision has been made for mounting the control valve to the tractor.



BARLAND

UNIGRADER

Applications include

- Farm-road maintenance
- Construction of new roads
- Preparation and maintenance of firebreaks
- Building and maintaining contours
- Land levelling
- Ditch digging
- Cutting furrows
- Irrigation earthworks

Gradeability .....

The Unigrader is more than able to cope with the toughest grading conditions. The design and angle of the blade, coupled with a weighted blade box - part of the machine and not a separate unit - and ballast-filled wheel arms ensure blade penetration even on the toughest road surfaces.

Versatility .....

The Unigrader can be operated offset from the tractor's line of travel for grading under trees or close to fences. The grader can be offset quickly by removing a securing pin, and repositioning the wheel arms at the required angle of offset left or right.

Unique .....

The design of the Unigrader is unique. Blade lift and tilt is hydraulic to give the instantaneous and precise blade control necessary for really accurate grading. The angle of the blade can be adjusted quickly and easily by the tractor driver, by means of a mechanical blade-locking device that offers a variety of angles. The Unigrader couples directly to the tractor's external hydraulic system by means of hoses fitted with quick-release couplings.

Unigrader specifications

Length	4 500 mm
Width Minimum	1 850 mm
Transport Length	3 750 mm
Maximum Height	1 000 mm
Mass	1 000 kgs
Blade Width	2 400 mm
Blade Height	550 mm
Blade Thickness	12 mm
Number of Blade Angles	3
Cutting Edges	2 of 1 200 mm x 155 mm x 15 mm
Cutting Depth	100 mm
Blade Lift	200 mm
Tyres	2 of 6.50 x 16 x 6 PR

BARLAND

BARLAND INDUSTRIAL EQUIPMENT CO.

Electron Avenue Extension, Isando 1600
PO Box 11 Isando 1600
Fax: (011) 929-0011
Tel: (011) 929-0111
[redacted]
Dominion & Associates