



ROAD DESIGN SOFTWARE FOR THE LOGGING INDUSTRY

Don Robinson

INTRODUCTION

Traditionally, the process of road design is carried out by producing on paper :

- A Plan
- A Longitudinal Section
- Cross Sections

in order that the designer/road builder can gain a three-dimensional "mind's eye" view of the proposed road.

When combined with quantity information (and mass haul diagrams) a complete costing of the construction work can be performed.

Unfortunately, the time involved in these operations has meant that full road design and drawings are seldom done in the forest industry, except for major roads.

To date, the advent of computer design packages for roading has done little to hasten the adoption of full design procedures. This stems from the fact that the drawings produced still require considerable skill in interpretation, and some instrumentation to satisfactorily perform costings, construction set out, and job supervision.

The aim of this brief report is to highlight the known road design packages available to the forest industry and to show some ideas that may be helpful in producing useful road design information from standard spreadsheet packages.

MANUAL ROAD DESIGN

The procedures and requirements for manual road design are very well developed and widely understood in the engineering community.

Conventional surveying techniques are used to fix points and give them coordinates of Northing, Easting and height.

This Northing and Easting information is used to plot a plan, and the combined information is used to plot a :

- Longitudinal Section (usually along the proposed or existing road line) - Figure 1.
- Cross Sections - Figure 2

By a process of trial and error a tentative road line is placed on both **plan** and **long section**. The design level, road width and batter information is used in the **Cross**

sections to draw in the proposed road. From the Cross Sections a knowledge of how much cut and/or fill is obtained, and quantity sheets and haul diagrams can be calculated and drawn.

Costing is then done on all component parts of the proposed road work to arrive at a construction estimate. This estimate usually follows a format similar to that shown in Figure 3.

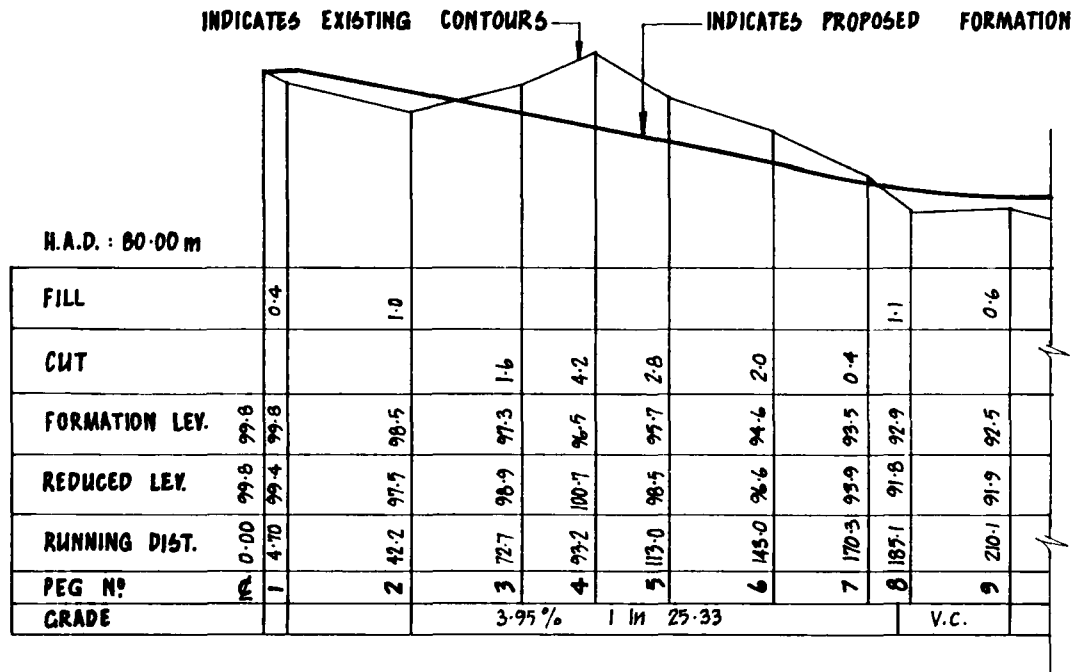


Figure 1 - Typical Longitudinal Section

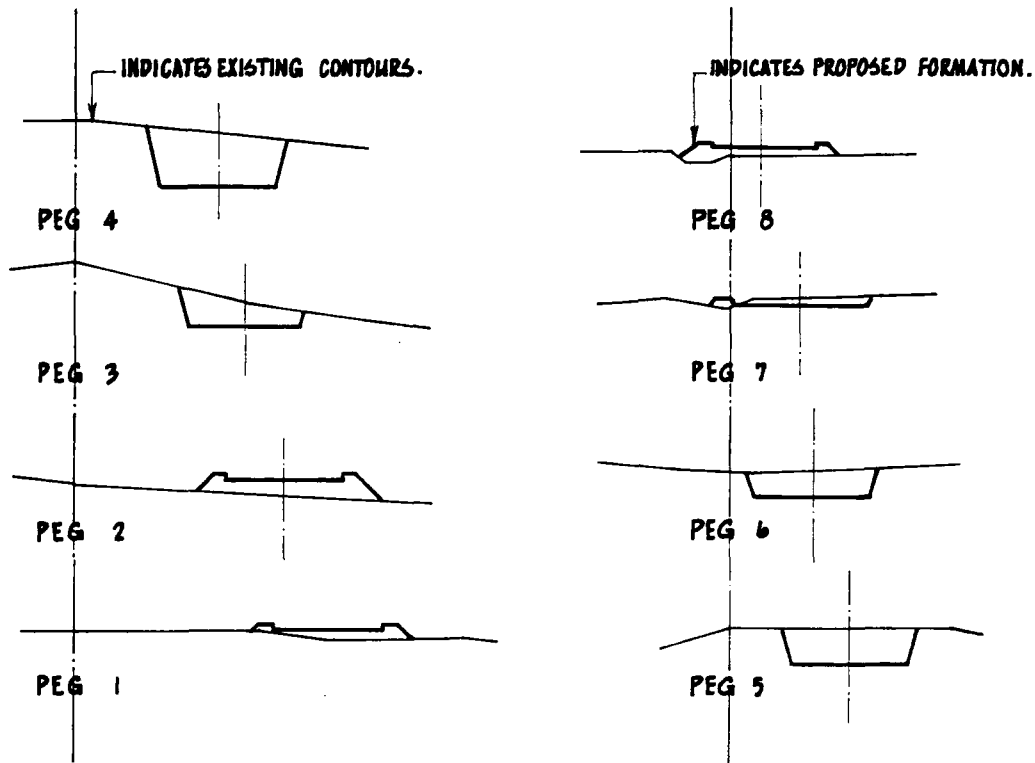


Figure 2 - Typical Cross Sections

JOB:	Rough Road	Date :
LOCATION:	West Forest	Map Ref :
Calculations by:		
Checked :		

ITEM NO	DESCRIPTION	QUAN.	UNITS	RATE	COST
1.	Survey and Design		LS		500
2.	Clearing	5200	m ²	1.00	5,200
3.	Earthworks	2000	m ³	.70	1,400
	Cut	1000	m ³	1.00	1,000
	Fill	1000	m ³	28.00	28,000
4.	Basecourse	2000	m ²	.30	600
5.	Seeding and Finish				
6.	Contingency				4,000
	<u>TOTAL COST</u>				<u>\$40,700</u>

Figure 3 - Example Estimate

The result is that even an experienced road designer will take many days to do a few kilometres of road design when using manual methods.

COMPUTERISED ROAD DESIGN

In computerised road design similar methods of survey and data collection are used, although the field collection may be partly automated with small hand-held computers. Manual design and drawing techniques are adapted for the computer and output from a pen plotter, similar to that produced manually, is produced very rapidly, with high precision and repeatability.

The designer needs to input data and decisions at various points depending on the particular program. Some programs will depend on operator input, for example to design curves, whereas others will endeavour to apply some stored criteria to the design process without operator intervention.

Features which may be available in computerised Road Design Systems:

- Compatible with a set of standards for Geometrics, Gradient etc.
- Accept electronic field notes directly by downloading from portable field computers or data-loggers.
- Balanced earthwork design either automatically or by user definition.
- Store and display control points or control features (stream crossings, road widths, etc.).
- Produce contract drawings and field pegging lists for setting out earthworks.
- Horizontal and vertical offsets from the survey line to aid setting out earthworks.

- Angle or azimuth systems for direction.
- Imperial or metric measurement.
- Prestored factors for:
 - (a) Batter slopes
 - (b) Watertable and road templates
 - (c) Compaction factors.
- Full Bench or Bench Cut and Fill templates.

1. 41 ENS - A Hewlett Packard HP - 41 Electronic Notebook System.
2. Cost estimating of Low Volume Roads using HP-41CV.
3. HANS-ON-ROAD DESIGN - Road design system (Figure 4).
4. LUMBERJACK - Road design system.
5. ROAD SURVEY PACKAGE - Road design system which fits Terasoft GIS system - available from Forest Research Institute, Rotorua.

Most computer road design packages will have some restrictions on:

- Computer Hardware
 Many American packages require the use of Enhanced Graphics Adapter screens (or VGA) and Arithmetic Co-Processor chips. Personal computers without these features will not run the road design package. Because of the mathematical nature of the road design an IBM-style PC-AT machine is the minimum requirement to get sufficient calculating speed, but a computer with a 386 processor is recommended.
- Curve widening may need to be added manually.
- Maximum number of points on each cross section may be limited.
- Sight distance checks may not be carried out on either vertical or horizontal curves.
- Alternative designs may destroy data for a design already completed.

Some example printouts are held at LIRA, and a running demonstration of HANS-ON-ROAD DESIGN is available by arrangement, for IBM-style PC's equipped with maths co-processor and EGA screen.

In addition to the above, the following packages may have some application:

1. FRI Harvest Planning Group Road Design Package.
 This runs on the Ministry of Forestry Vax computer and may be available by arrangement. There are no plans to make it available on personal computer.
2. AUTOCAD and various enhancements can be used by knowledgeable practitioners to do road design work.
3. FLRDS (Forest Level Road Design System) for personal computers. This package developed by the US Forest Service may be available - specific enquiries should be made through LIRA. FLRDS can only be operated on a Personal Computer with:

SPECIFIC PACKAGES FOR ROAD DESIGN

Information on the packages the author saw while in North America in late 1987 is given in LIRA Project Report No 36. These include:

- (a) 10Mb of hard disk available for use
- (b) 640K RAM

HANS_ON Road Design		MAIN MENU	Version B.00.00
DATA ENTRY	DESIGN REPORTS	GRAPHICS	
<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Survey</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Template</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Grade</div> <div style="border: 1px solid black; padding: 5px; margin-top: 20px;">Utilities</div>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Earthwork</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Self Balance</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Clear & Seed</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Slope Stakes</div> <div style="border: 1px solid black; padding: 5px; margin-top: 20px;">EXIT</div>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Sections</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Traverse</div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">Profiles</div> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;">CAD Files</div>	
		MJH . . . arrow keys, then ENTER	

Figure 4 - Example Printout Main Menu HANS-ON-ROAD Design

- | | |
|---|---|
| <p>(c) Numeric Co-processor</p> <p>(d) EGA or VGA graphics</p> <p>(e) An 11 x 17 plotter is recommended as the minimum output device.</p> | <p>- earthwork quantities and corrections along with Mass Haul diagram information</p> <p>- co-ordinates from bearings and distances.</p> |
|---|---|

SEMI-AUTOMATED ROAD DESIGN

Between the fully manual system and the fully automated there is a fertile area for innovation and original thought.

Programmable calculators, such as the CASIO 702P, HP-41C or the SHARP 1500 series, are all capable of being programmed to calculate :

- gradients
- curves (both horizontal and vertical)

These calculations are made in a manner similar to that which would apply to manual calculation. Examples are available in Forest Engineering Institute course notes and various publications in LIRA's library such as "Engineering Field Notes", or any good text book on road design.

Digitisers for measuring areas of cut and fill are an economic alternative to the traditional or electronic planimeter.

Spreadsheets can be used in producing both Plans and Longitudinal Sections.

For example, it is very easy to arrange the field measured data in columnar form:

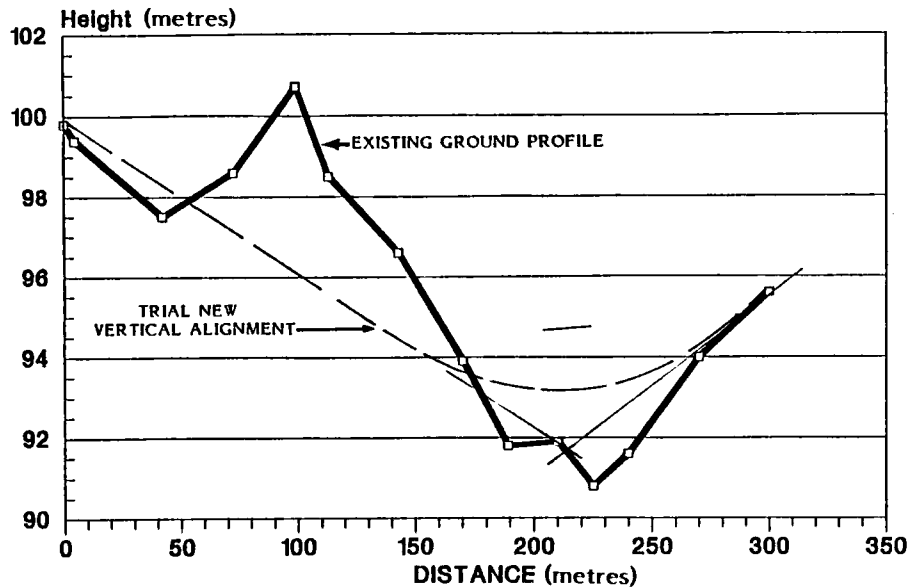


Figure 5 - Example Spreadsheet - Longitudinal Section

Distance	Reduced Level	Formation Level
0	99.80	99.80
4.7	99.40	99.80
42.2	97.50	98.50
⋮	⋮	⋮

The graphing facility in the spreadsheet is then used to produce a Longitudinal Section (Figure 5).

The traverse bearing and distances can also be entered on a Spreadsheet in columnar form. This is then plotted using the graph facility in conjunction with the scaling facility and either a 15" wide printer or a plotter to produce a plan in a similar fashion. This technique depends on a clear understanding of what is involved and how the XY co-ordinate system relates to an X-Y graph in the Spreadsheet. Its use is much more limited than the Longitudinal Section shown in Figure 5.

CONCLUSIONS

The available road design software could be economic if road design is a full-time occupation for at least one person. Even then the skill requirement is high and this

means that full road design will probably remain in the realm of the very experienced person in at least the near future.

However, some spreadsheet and programmable calculator techniques can be adapted to make the more tedious operations a little more pleasant and much more efficient. This area is the most likely to be of use in the forest industry, especially for part-time road designers.

REFERENCE

Robinson, D. (1988) : "Jubilee Scholarship - A Study Tour to the 4th International Low Volume Roads Conference and Roading Field Operations 1988", LIRA Project Report No 36.

LIRA NOTE

Forestry roading people who have developed and used programmable calculators or spreadsheets for road design, may publish their approach in a LIRA Technical Release or a Newsletter item. Contact the Extension Officer at LIRA.

For further information, contact:

N.Z. LOGGING INDUSTRY RESEARCH ASSOC. INC.
P.O. Box 147,
Rotorua, New Zealand.

Fax: (073) 462-886

Telephone (073) 487-168