ReCAP
Research for Community Access Partnership

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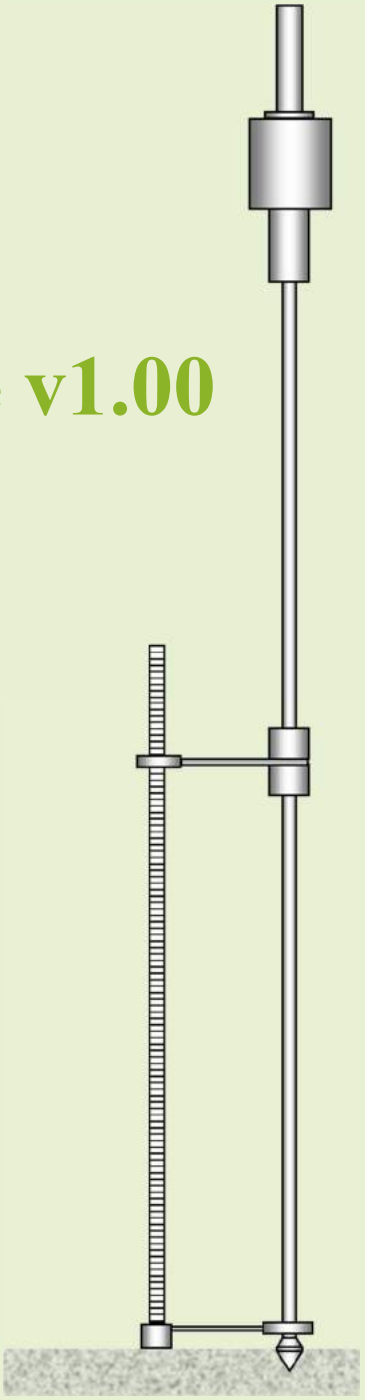
User Manual for the ReCAP LVR DCP Software v1.00



September 2020

Preface

The Malawi Design Manual for Low Volume Sealed Roads Using the DCP Design Method that was developed under AfCAP in 2013 has been revised and updated, together with the associated AfCAP LVR DCP software and User Manual, to take account of the latest developments in DCP-DN technology. This has led to the development of a generic manual for the *Pavement Design of Low Volume Roads Using the DCP-DN Method* (August 2020), as well as an upgraded version of the software – ReCAP LVR DCP v 1.00 and a revised User Manual. This document provides the contents of the new User Manual.

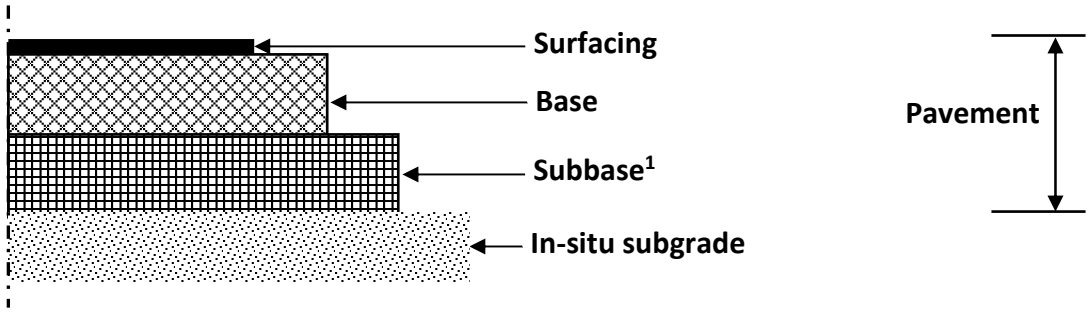
Keywords

Low Volume Roads (LVRs), Dynamic Cone Penetrometer (DCP), DCP-DN Design Method, DN Value, Pavement Balance.

Terminology

The terminology used to describe various components of a low volume road is illustrated below for ease of reference in the use of this Manual.

Pavement[1]



Main components of a LVSR pavement

[1] Subbase can be from imported material or an improved in-situ subgrade layer.

Acronyms, Units and Currencies

A	Deviation of DCP data from Standard Pavement Balance curve (SPBC), in %.mm
AASHTO	American Association of State Highway and Transportation Officials
ABD	Averagely-Balanced Deep structure
ABI	Averagely-Balanced Inverted structure
ABS	Averagely-Balanced Shallow structure
AfCAP	Africa Community Access Partnership
BN	Balance Number
BN_{100}	Number of blows as a percentage of the DSN_{800} required penetrating 100 mm
CBR	California Bearing Ratio in %
CSIR	Council for Scientific and Industrial Research
D	Pavement depth in mm or in %
DCP	Dynamic Cone Penetrometer
DN	DCP penetration in mm/blow
DN	DCP Number (mm/blow) – also known as “rate of penetration”
DSN_{450}	DCP Structural Number (number of DCP blows to 450 mm depth) – for LVRs.
DSN_{800}	DCP Structural Number (number of DCP blows to 800 mm depth)
E_{80}	Equivalent standard 80 kN axles (See MESA)
HVS	Heavy Vehicle Simulator
LSD	Layer Strength Diagram
LVR	Low Volume Road
MESA	MIllion Equivalent Standard Axles (80 kN) [Traffic demand]
MISA	MIllion Standard Axles (80 kN) [Pavement Bearing Capacity]
PBD	Poorly-Balanced Deep structure
PBI	Poorly-Balanced Inverted structure
PBS	Poorly-Balanced Shallow structure
ReCAP	Research for Community Access Partnership
SPBC	Standard Pavement Balance Curve
TLC	Traffic Load Class for LVRs
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, UK)
WBD	Well-Balanced Deep structure
WBI	Well-Balanced Inverted structure
WBS	Well-Balanced Shallow structure

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1. Introduction

1.1 Background

The use of the DCP for pavement design purposes was developed in the mid-1960s and 1970s in South Africa based on the back analysis of numerous (more than 1100) road sections located in a variety of environments (traffic loading, climate and materials) that typically prevail in many tropical and sub-tropical countries of the world. This led to the development of a structural design catalogue based on DN (penetration in mm/blow) values for a range of design traffic loadings. The method has undergone continuing refinements based on the experience of its use in a number of Southern African countries. This has culminated in the development of a generic manual for the Pavement Design of Low Volume Roads Using the DCP-DN Method (August 2020).

The first version of AfCAP LVR DCP v 1.03 software was produced in mid-2016. Based on its subsequent use, a number of improvements have become necessary to reflect the latest refinements in the DCP design method. This has led to the development of an upgraded version of the software renamed - ReCAP LVR DCP v1.00 - which was produced in August 2020. This version caters to the design of both unpaved and paved low volume roads (LVRs).

1.2 Purpose

The purpose of this Manual is to guide users, in a step-by-step manner, in all the procedures required to undertake the complete design of a low volume road. The design examples presented are based on the latest version of the software. The Manual should be read in conjunction with the generic DCP-DN Design Method, which provides supporting documentation on all aspects of LVR design.

1.3 Scope

The upgraded design software is presented in a completely new, more user-friendly format; it offers colour, menu screens, full-screen edit, and hyperlinked help. The complementary User Manual is divided into five sections, which collectively guide the user through the various procedures required to ultimately print out a design report.

A summary of the contents of each section of the User Manual is presented below:

Section 1: Introduction (this sections). Presents the background to the development of the User Manual and its purpose and scope.

Section 2: Installing and Running the Software: Guides the user on how to install the software and create a new project. It also Illustrates how to run the software to create either (a) a field project for recording and analysing DCP survey data for subsequent pavement design purposes, or (b) a laboratory project for recording and analysing laboratory DN test data.

Section 3: Field Projects: Guides the user on all the procedures required to ultimately produce a design report, including the functions of the Menu Options, the manner of entering and analysing the DCP survey data, and undertaking a complete pavement design.

Section 4: Laboratory projects: Guides the user on all the procedures required to undertake laboratory DN tests of in-situ and borrow pit materials as an input into the pavement design.

1.4 On-screen Navigation in the User Manual

Hyperlinks in the User Manual provide for easy navigation to search for help on the various topics, as follows:

- Click "Help" in the software to bring up the User Manual.
- Scroll to display the Table of Contents, if required.
- Click on the relevant topic in the Table of Contents to bring up the selected section in the Manual.
- Click on any of the numbered section headings to quickly navigate back to the Table of Contents.

2. Installing and Running the Software

2.1 Installation

The software installation follows the standard Windows installation process, which is activated from the installation file:

ReCAP LVR-DCP Install v1.00.exe

After the software is successfully installed, the following short cut icon will be on your computer screen.

Figure 2-1: Desktop short-cut icon

2.2 Starting the program

To start the software, double-click the ReCAP LVR-DCP short-cut icon. The opening screen in Figure 2-2 will be displayed.

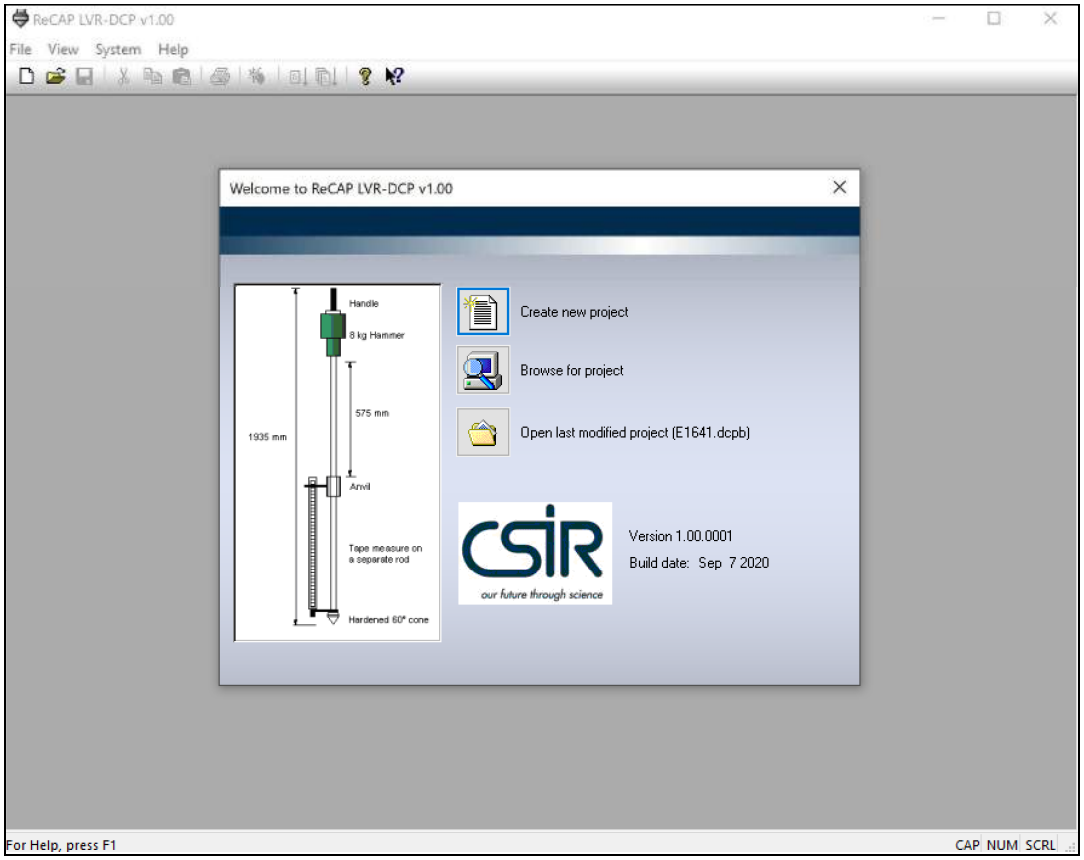


Figure 2-2: Opening screen

To proceed, one of the three options presented on the screen can be selected. Alternatively, by pressing 'Escape', one can proceed using the menu on top of the screen. The following steps will be the same in both cases.

- Create a new project: This can be either a Field or Laboratory project, which is described separately in Sections 3 and 4, respectively.

- Browse for project: This simply opens the last folder used for retrieving a project file. It is therefore recommended to create a folder for storage of all ReCAP LVR DCP project files.
- Open last modified project: This will open the last project that was worked on.
- By pressing the 'Escape' key, a list of the last four projects that were modified will appear in the File menu, as shown in Figure 2-3.

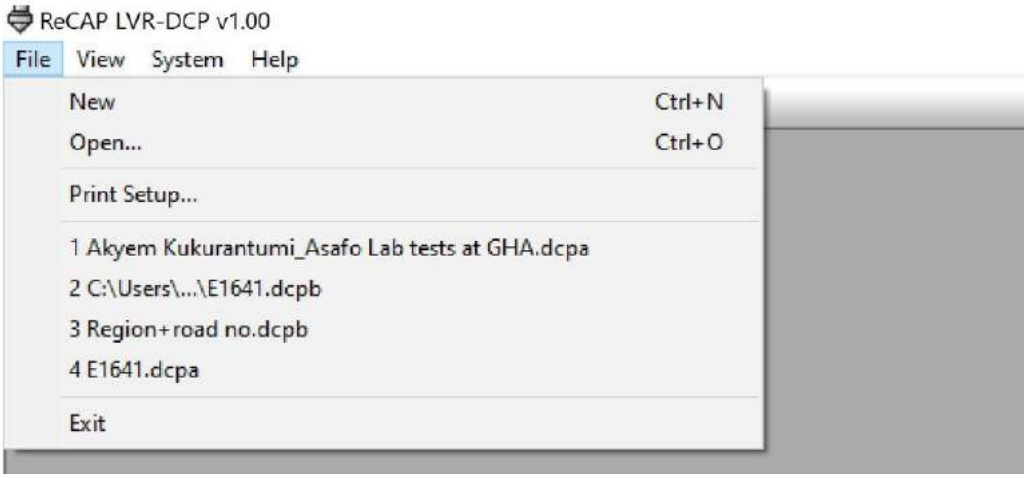


Figure 2-3: Last four modified projects available from the File menu

2.3 Starting a new project (File menu)

When selecting "New project" from the opening screen or the file menu, the following screen is displayed for selection of project type:

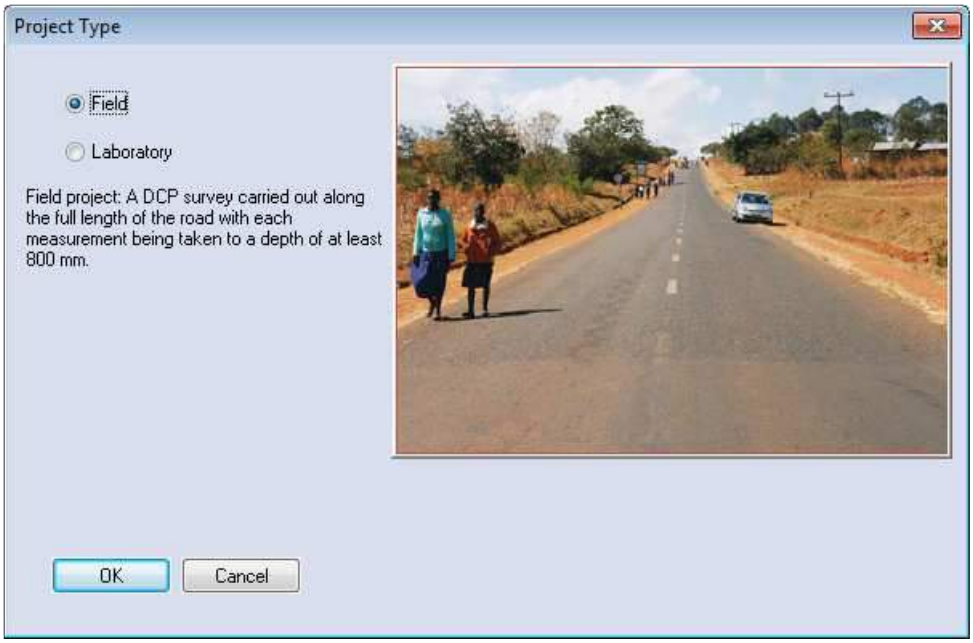


Figure 2-4: Selection of new project type

- Field projects are for recording and analysis of DCP survey data and pavement design.
- Laboratory projects are for recording and analysis of laboratory DN test data (some of which will be input into the Field project files).

The procedures for field and laboratory projects are entirely different and are therefore described in separate sections to avoid any confusion.

3. Field Projects

3.1 New Project Header Information

When the user starts a new ReCAP LVR-DCP project, the project header information screen appears. This screen provides an interface for the user to define the Region, Road Number and Project Date for field projects. The screen also displays the path and name of the ReCAP LVR-DCP project file. Select the OK push-button when you have finished entering or updating the required information or select Cancel you want to discard the new/updated information and start again.

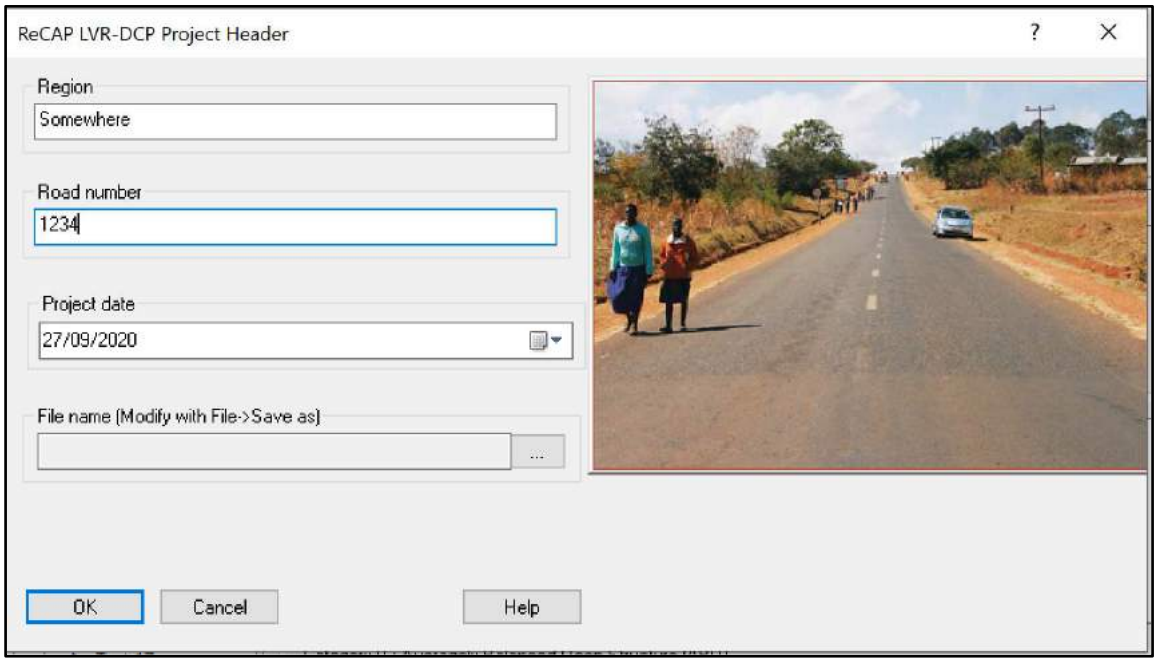


Figure 3-1: Project header information

The following is a list and descriptions of the information required on the DCP Field form, which must be entered in the DCP project file.

- "Region": A region name which will be shown on the analysis report needs to be given. The user should enter the name of the region where the DCP investigation was undertaken, for example, “Southern Regions”.
- "Road Number": The Road Number for the road where the DCP investigation was undertaken will also be displayed on the analysis report.
- "Project Date": The Project Date (dd/mm/yyyy) should reflect the date on which the DCP investigation was undertaken, or the date when the investigation started in case the DCP investigation process spanned more than one day.
- File name: Select a file name to store the DCP project by clicking the ... button next to “File name” (Modify with File - > Save As). Use descriptive file names to clearly distinguish between projects.

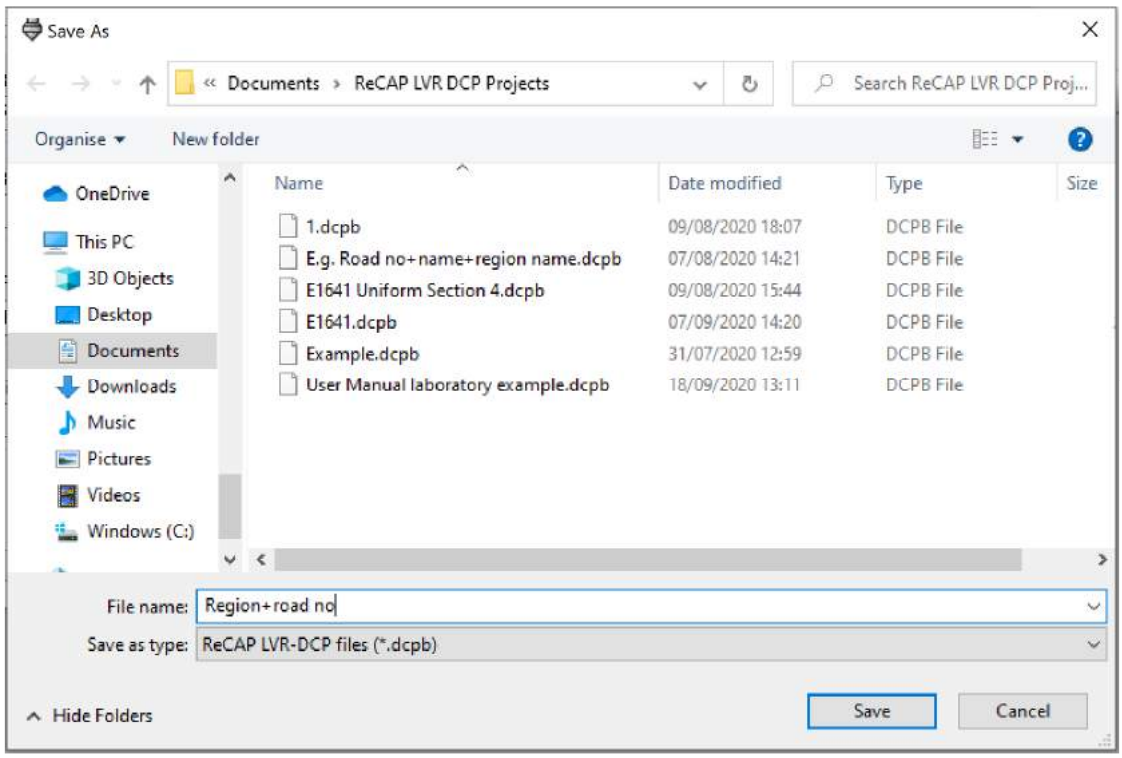


Figure 3-2: Storage of files in a common DCP project file folder

After entering an appropriate file name and saving the file, the main data entry screen will be displayed.

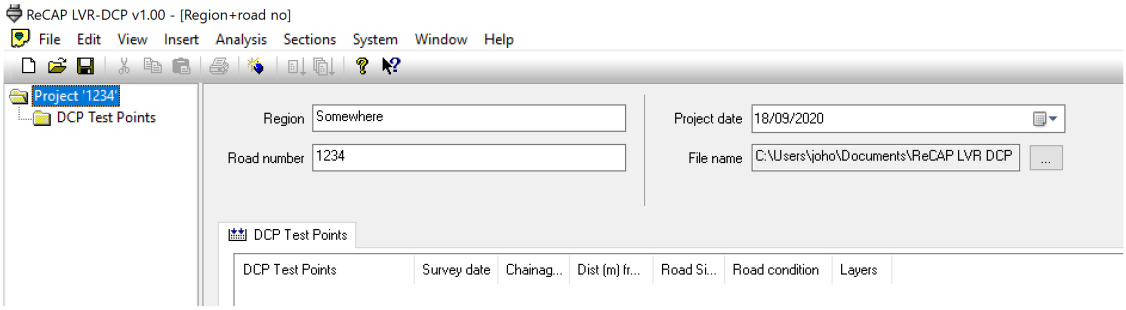


Figure 3-3: Main data entry screen

3.2 Menu Options

The menu on top of the screen follows the standard Windows menu convention, as described below:

3.2.1 File

Opens the file menu

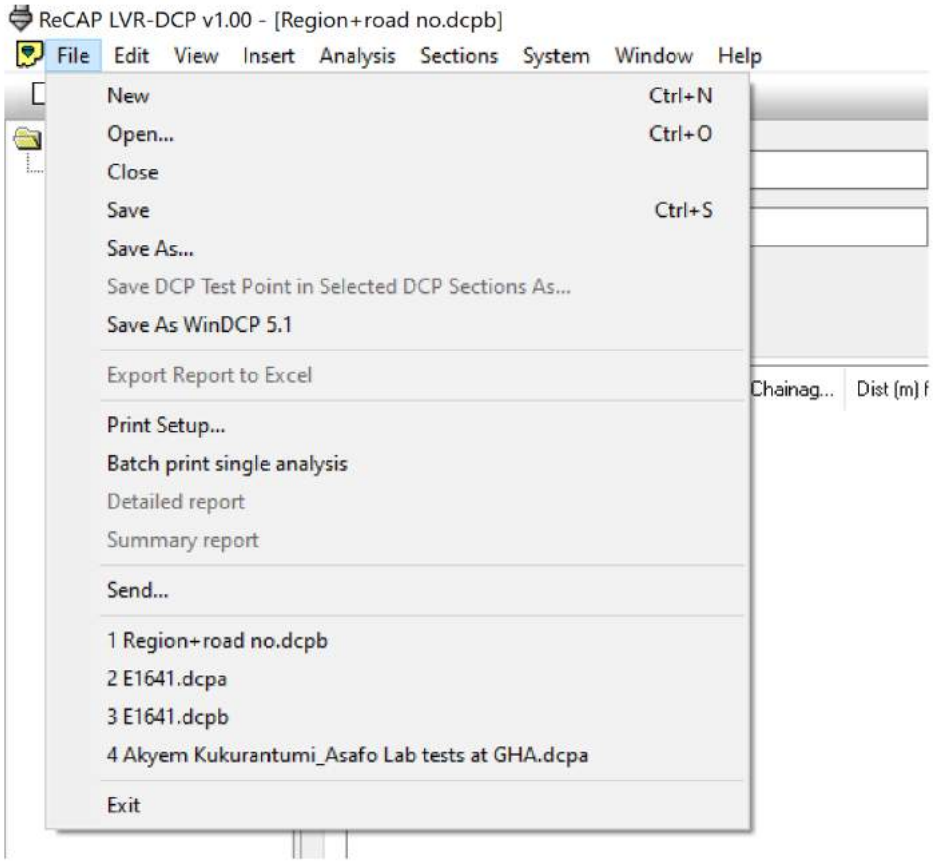


Figure 3-4: File menu

3.2.2 Edit

Standard Windows Edit menu

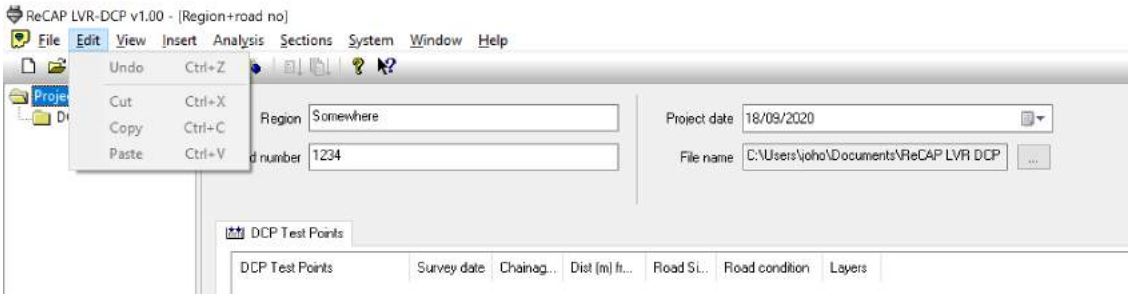


Figure 3-5: Edit menu

3.2.3 View

Standard Windows View menu with option for arranging the display of DCP test points.

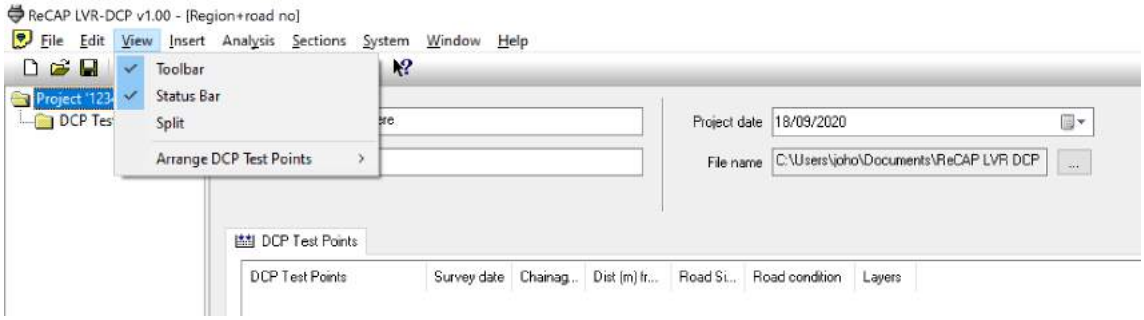


Figure 3-6: View menu

3.2.4 Insert

Provides an option for entering a new DCP test point.

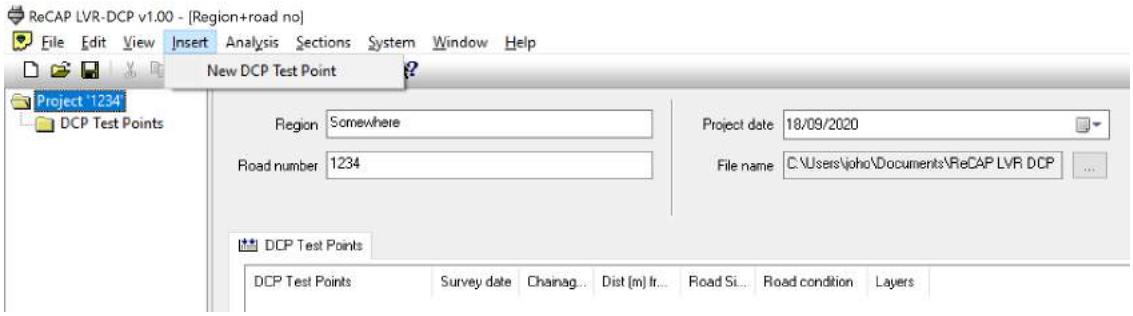


Figure 3-7: Insert menu

3.2.5 Analysis

Provides options for Single Point and Multiple Point analysis. These options are disabled if no DCP test point data have been entered.

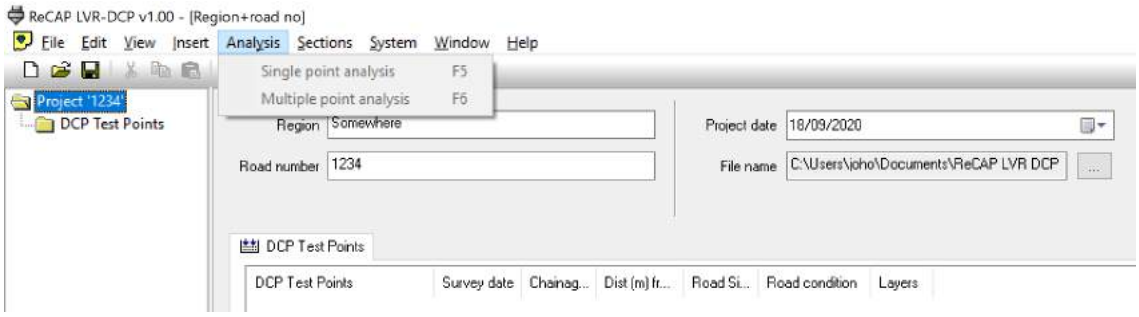


Figure 3-8: Analysis menu

3.2.6 Sections

Menu to be used in the design process. This is disabled until DCP test point data have been entered.

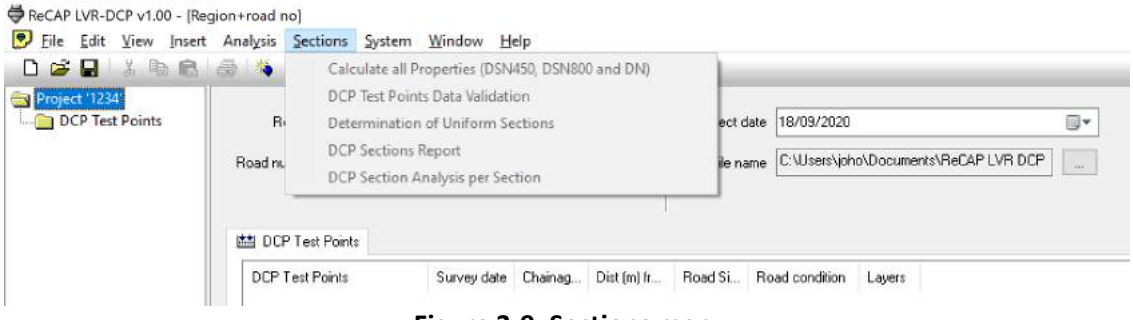


Figure 3-9: Sections menu

3.2.7 System

System set-up, TLC Design Curves configuration and Report settings are carried out from this menu, as shown below.

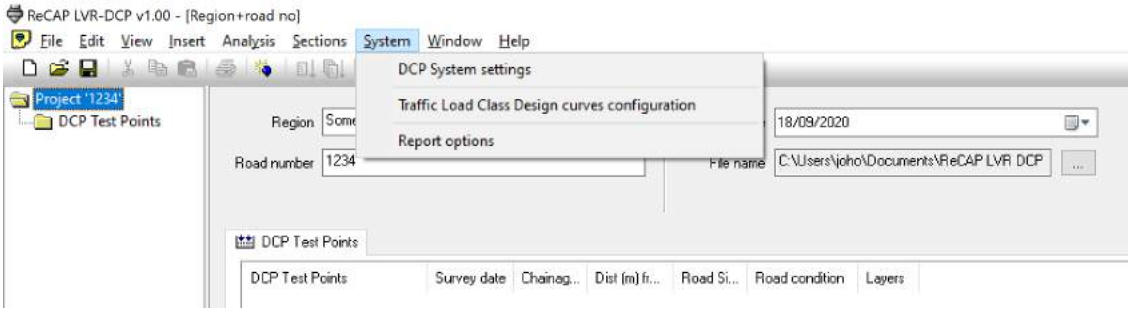


Figure 3-10: System menu

DCP System settings: Provides options for the use of percentiles/reliability level for the design and what to display in the DCP Sections Report. The default option is not to use percentiles and to display "Layers only" (i.e., the weighted average DN per layer) in the DCP point analysis. If "Use Percentiles/reliability level" is selected, the DCP test point analysis window and the DCP Sections Report will display Layers and Percentiles (Figure 3-11).

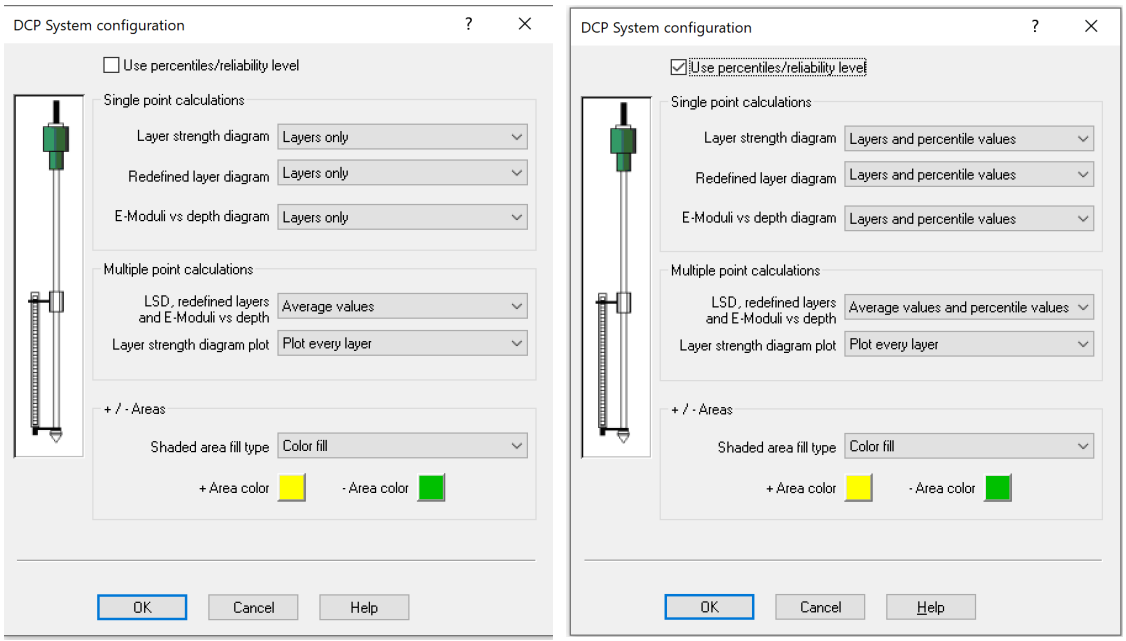


Figure 3-11: DCP System configuration

Traffic Load Class design curve configuration: The user can select from the standard TLC design curves to be used for the DCP test point analysis (Figure 3-12).

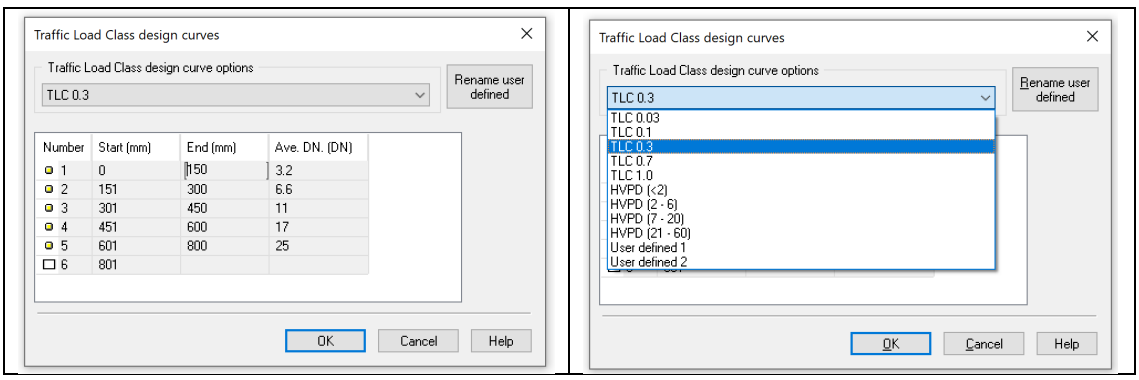


Figure 3-12: TLC design curves

The following options are provided:

- The TLC design curves to be used for upgrading from unpaved to paved
- The HVPD (heavy vehicles per day) to be used for the design of gravel roads
- With the User-defined option, the user can define new catalogue values and layer configurations, as described in the DCP-DN Design Manual.

Report Options: The user can decide what to display in the on-screen reports. It is recommended to use the default option with all boxes ticked, as shown in Figure 3-13.

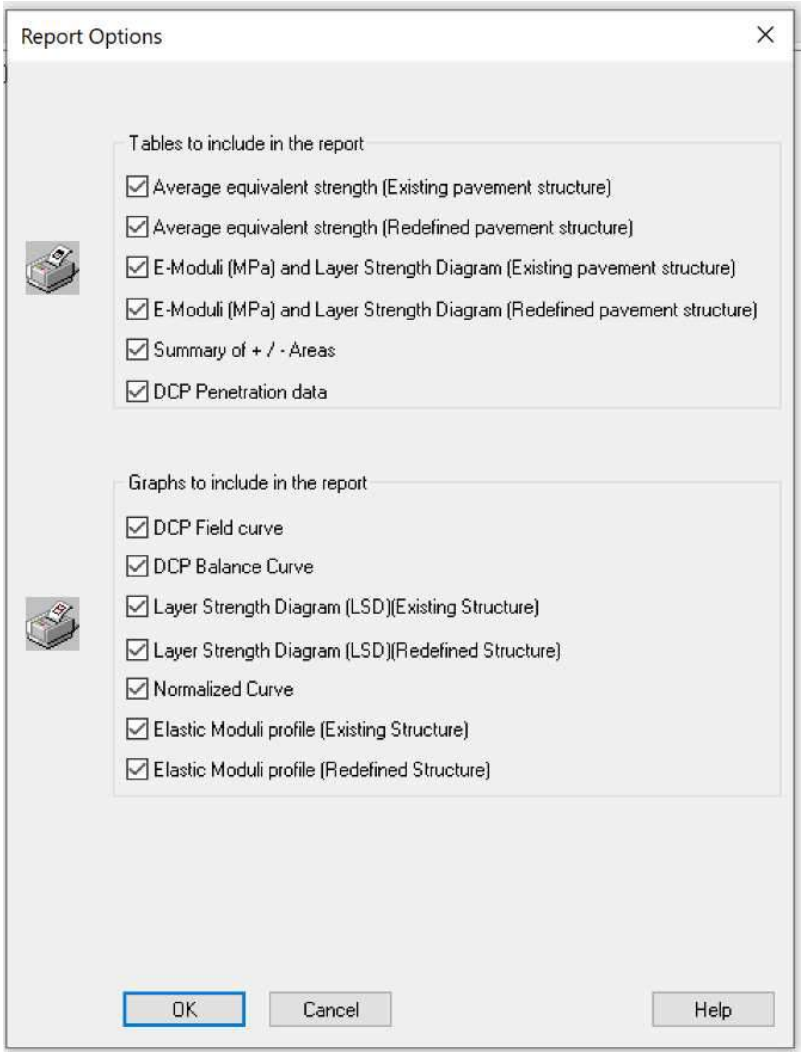


Figure 3-13: Report options

3.2.8 Window

This provides options for how to display open files on the screen. From this menu, several projects can also be opened at once by selecting in the list of projects at the bottom of the menu.

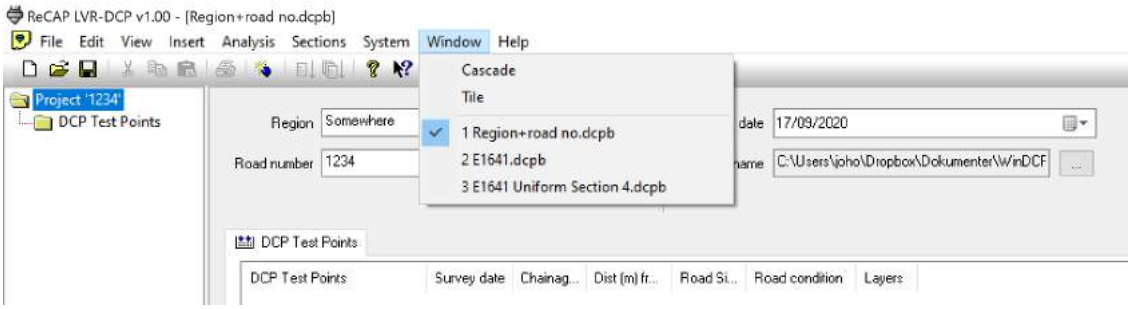


Figure 3-14: Window menu

3.2.9 Help

This will bring up the User Help file (this file), in which hyperlinks will take the user directly to the selected topic.

3.2.10 Short-cut icons

Short-cut icons are provided below the menu for the standard functions (New file, Open Save, Cut, Copy, Paste and Print).

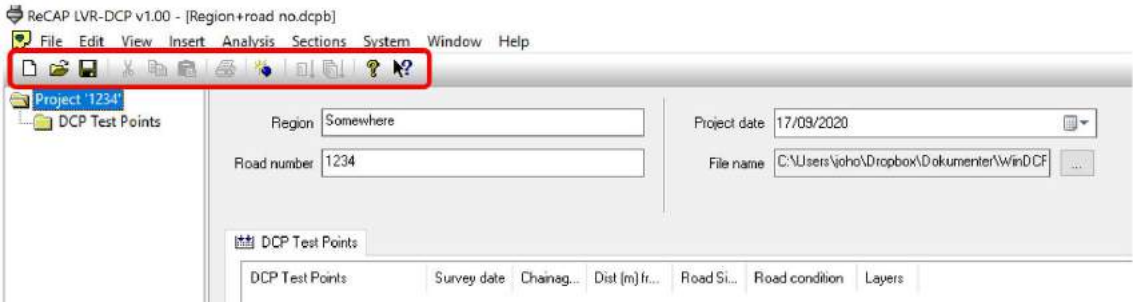


Figure 3-15: Short-cut icons

In addition, the standard short-cut icons, the following icons provide short-cuts for:

- New DCP Test Point 
- Single point analysis 
- Multiple point analysis 

3.3 Entering DCP survey data

3.3.1 DCP test point information

By selecting the "Insert New DCP Test point" from the menu or clicking  , the data entry screen is displayed. The procedure for entering DCP test point information (Figure 3-16) is as follows:

- DCP tests in field projects are referred to as "DCP Test Points" and are assigned numbers in increasing order as they are entered.
- The test points can be renamed, if required, by clicking the "Rename" button.
- Then enter the data in the following order:
    - Chainage for the test point
    - Road width at the test point (can vary along the road)
    - Distance of the test point from the Centre Line. If the distance is set to zero, the Road Side is automatically set to CL. If a distance from CL is entered, the Road Side must be set to either LHS or RHS (CL is disabled).
    - Survey date
    - Road condition (descriptive only, does not affect the design)
- Set the number of blows per reading (the default is 5, but this can be varied) if the DCP readings are taken with a fixed number of blows. If the number of blows in the test is varied (preferred in soft ground and will also make it easier to identify weak or hard interlayers), tick the "Variable blows" box.

- Number of layers default to 5 and cannot normally be changed. However, it is possible to determine a new catalogue as described in the DCP-DN Design Manual, in which case the layer configuration and thicknesses may be different.
- Select the relevant TLC for the road based on the Traffic Load estimate.
- The "Change TLC for all DCP Test Point" provides a quick means of changing all test points to a new TLC for analysis.
- Enter notes for each test point (conditions on site, the weather during the survey, etc., as required).
- For new DCP test points, the information that does not need to be changed is transferred from the previous point.

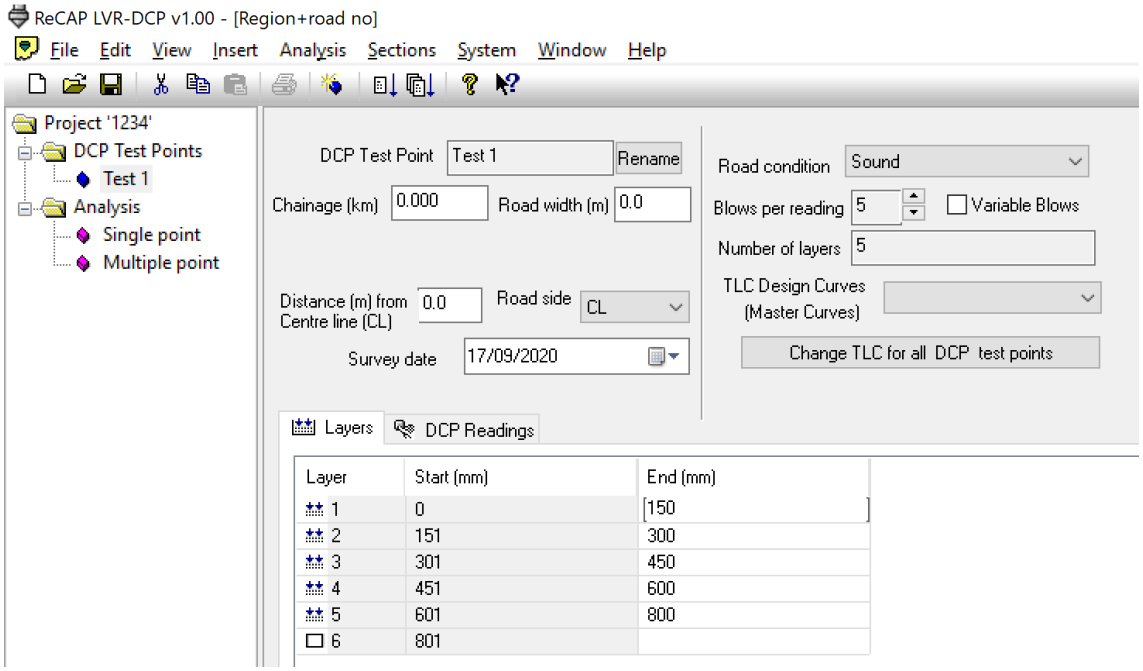


Figure 3-16: DCP test point data entry screen

3.3.2 Entering DCP readings

Having entered all the basic information as described above, the DCP readings can be entered by clicking the "DCP Readings" tab, as shown below.

- If fixed blows per reading were selected (Figure 3-17), only the DCP readings must be recorded.
- If "variable blows" was selected (Figure 3-18), both the number of blows and the readings must be recorded.
- The 'Tab" key can be used to move from one cell to the next in the right order when entering data.
- Care must be taken to enter correct readings (in ascending order). If one or more readings have been entered in descending order, an error message will be displayed when analysing the DCP test point data, at which point the reading may be corrected.

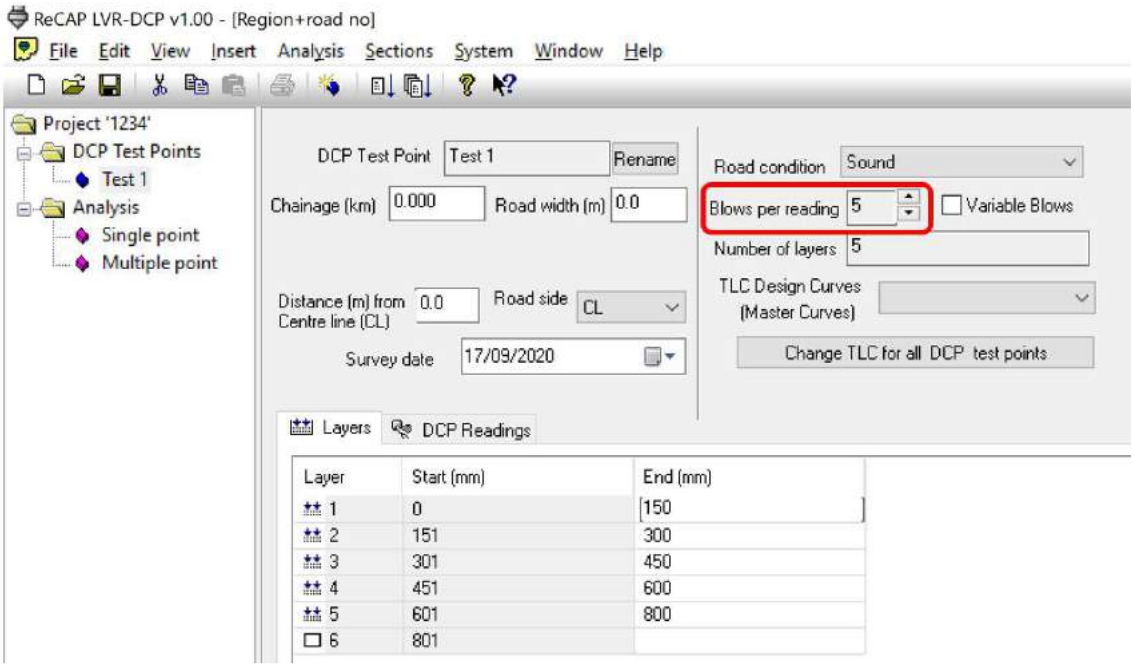


Figure 3-17: Entering DCP readings for fixed blows per reading

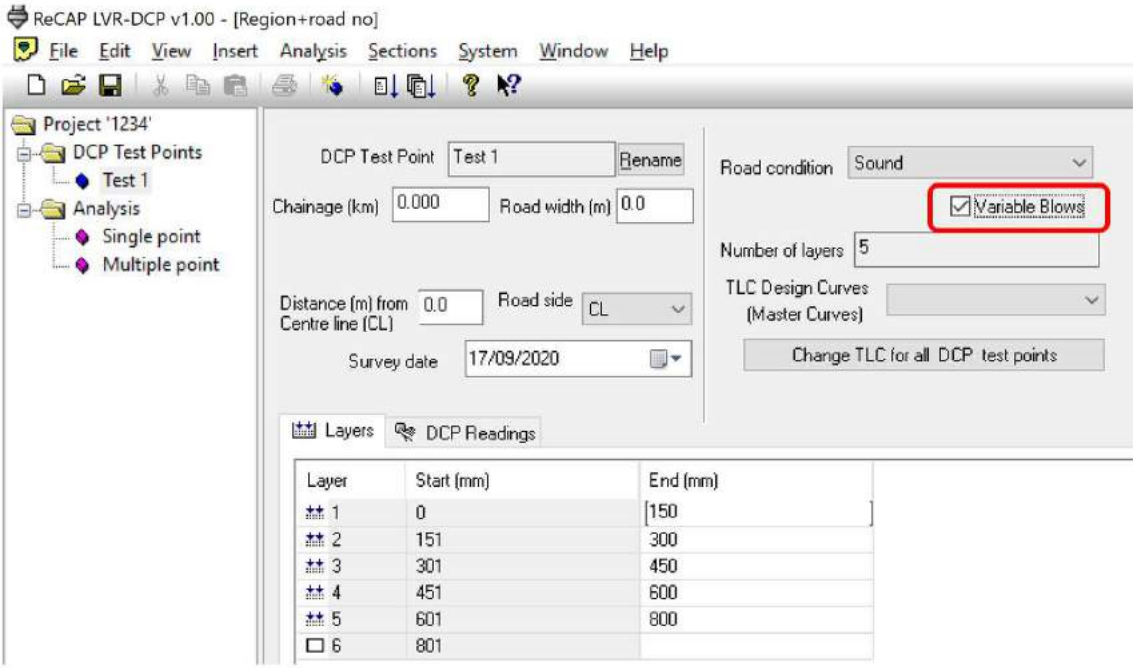


Figure 3-18: Entering DCP readings for variable blow per reading

DCP readings may also be imported from an Excel spreadsheet, as illustrated below:

- Insert a new Test point, as explained above, and click the DCP Readings tab to display the empty DCP Readings screen.
- For data with fixed blows per reading:
  - Copy only the column with the DCP Readings (Figure 3-19).
  - Make sure the "Variable blows" option is not selected.
  - Paste the data into the test point readings by pushing the "Paste" button at the bottom of the screen.

- Preferably, but not strictly required, adjust the "Blows per reading" to the same value as the one actually applied for that test point (in this case 5, as indicated in Excel in the cell above the readings).

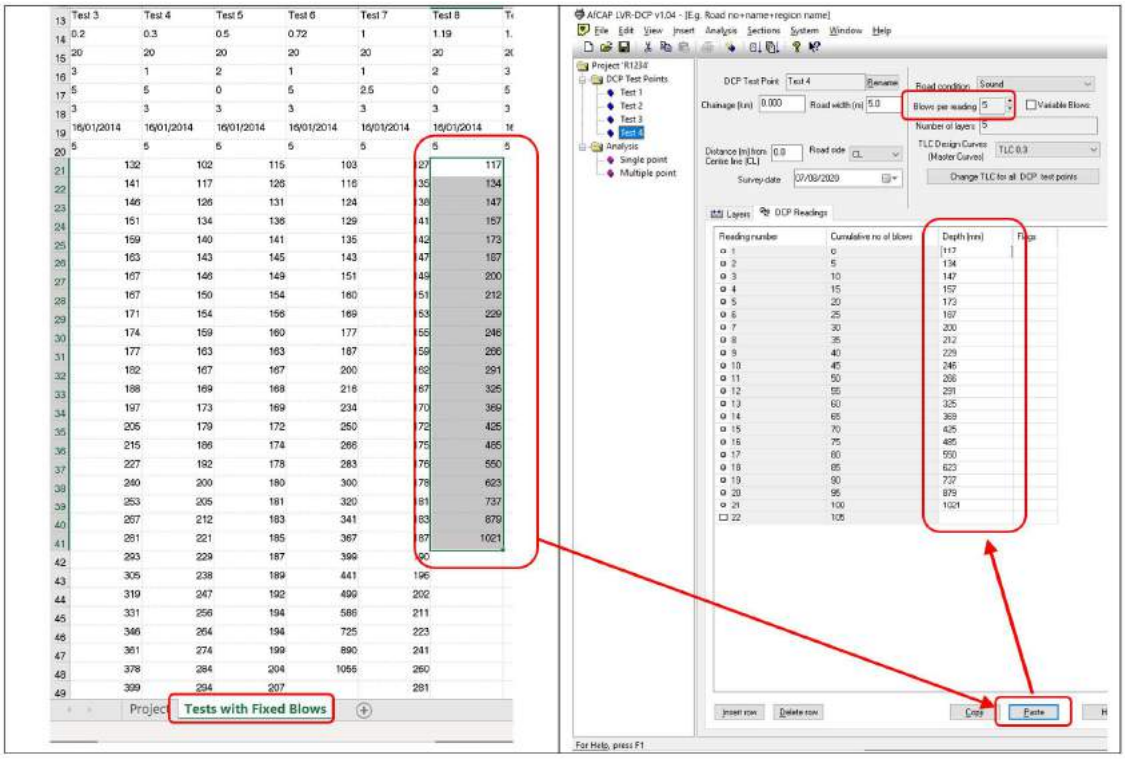


Figure 3-19: Copying DCP readings with fixed blows from Excel

- For data with variable blows per reading:
  - Copy both the 'blows per reading' and the 'readings' column in the Excel sheet (Figure 3-20).
  - Make sure "Variable blows" is selected.
  - Paste the data by pushing the "Paste" button at the bottom of the screen.

Note that neither the normal Windows Ctrl+v command for pasting nor the Paste option in the Edit menu will work for this operation.

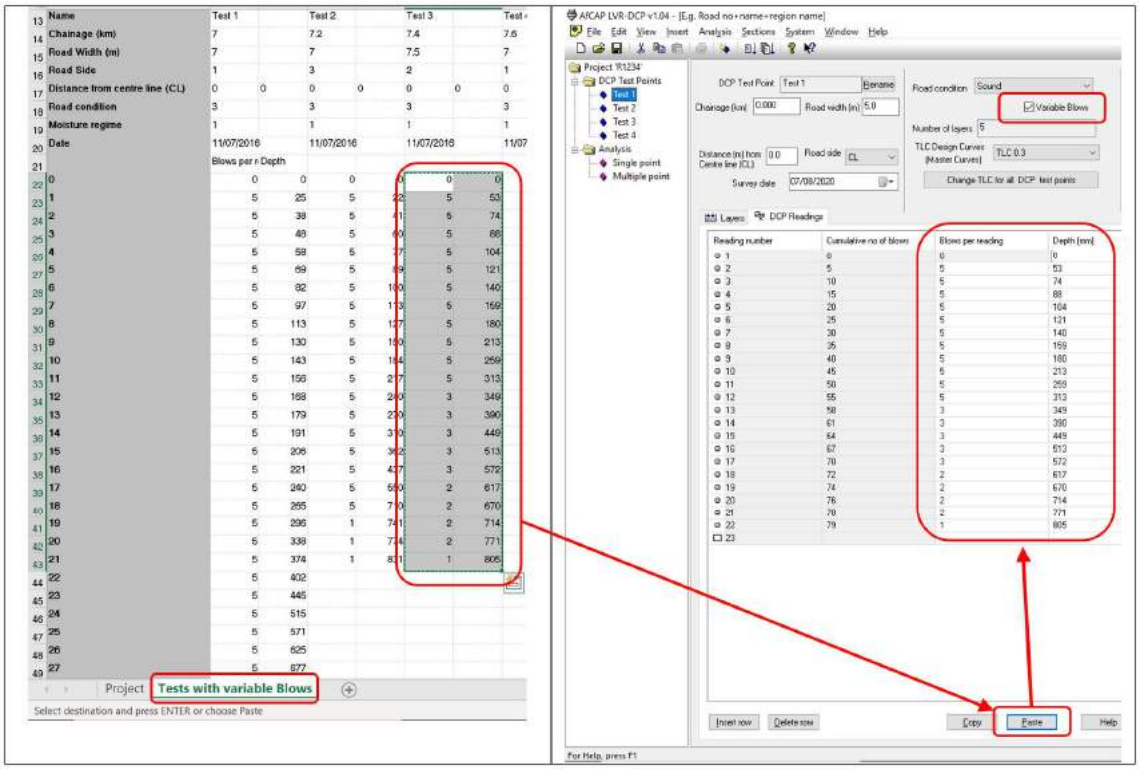


Figure 3-20: Copying DCP readings with variable blows from Excel

3.3.3 Opening older DCP projects

The software is backward compatible with previous versions of the ReCAP LVR-DCP program as well as the older WinDCP 5.1 program. Older projects saved in the *.dcpa or *.dcp format can be opened for data analysis and design as shown:

- Select File/Open from the File menu.
- Select the relevant file format (Figure 3-21).
- Select the project and click open (Figure 3-22)

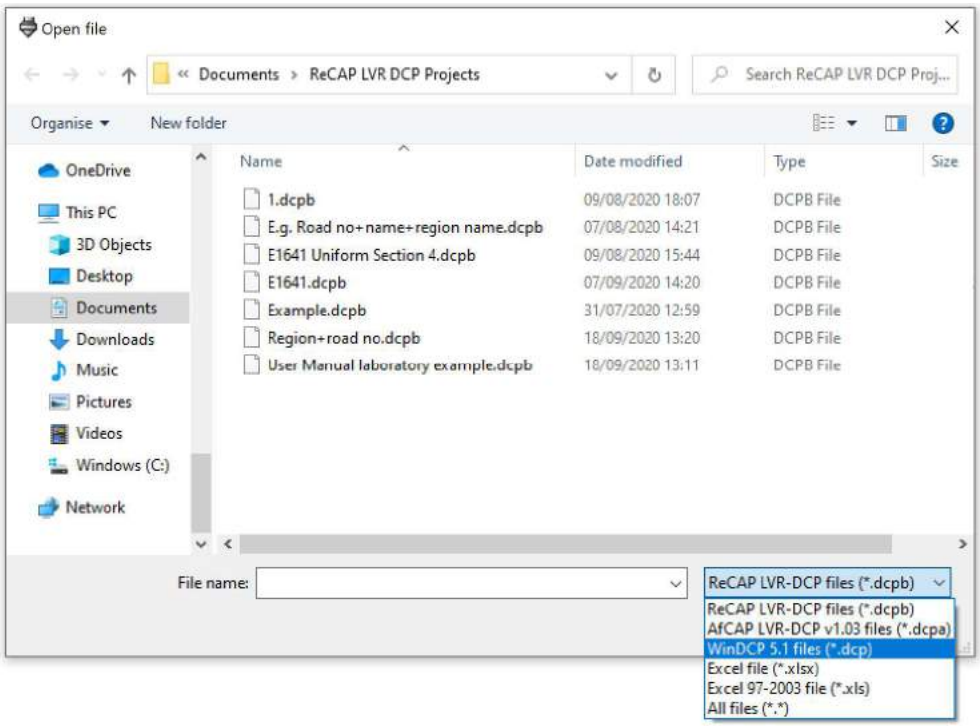


Figure 3-21: Selection of file format for older projects

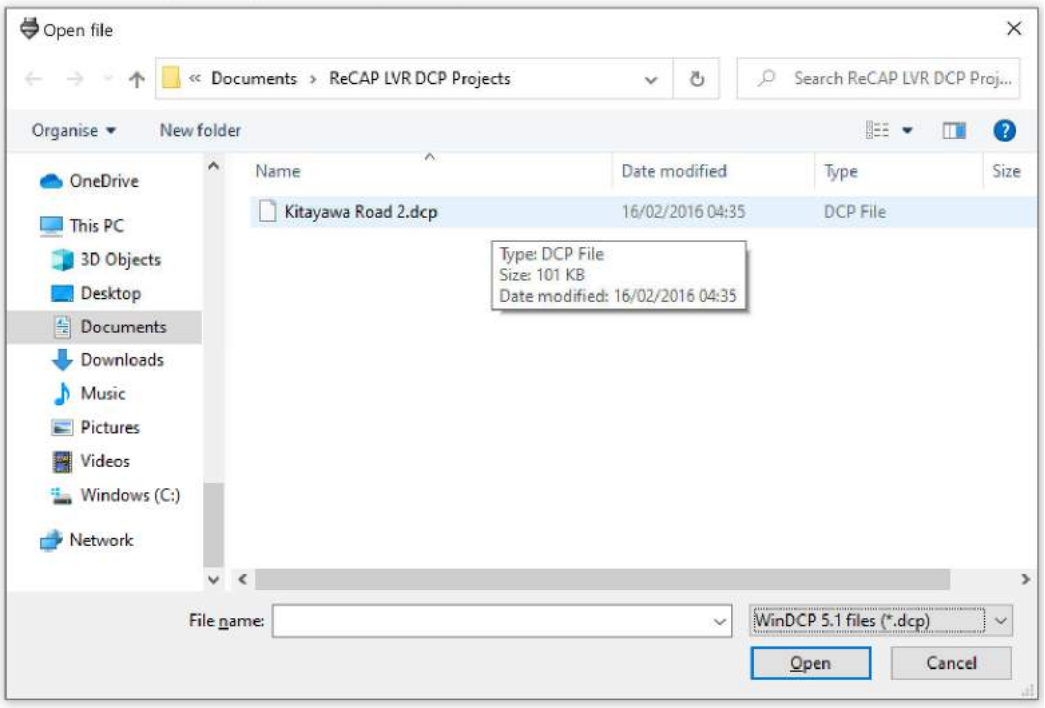


Figure 3-22: Selection of older DCP project

3.4 Data Analysis

After entering the DCP readings, the DCP data can be analysed, either for test points or multiple test points.

3.4.1 Single point analysis

- Click the "Single point analysis" icon or select the select "Single point analysis" from the Analysis menu.
- Select the test point to analyse (Figure 3-23) and click OK.
- The output from the analysis is shown in Figure 3-24.

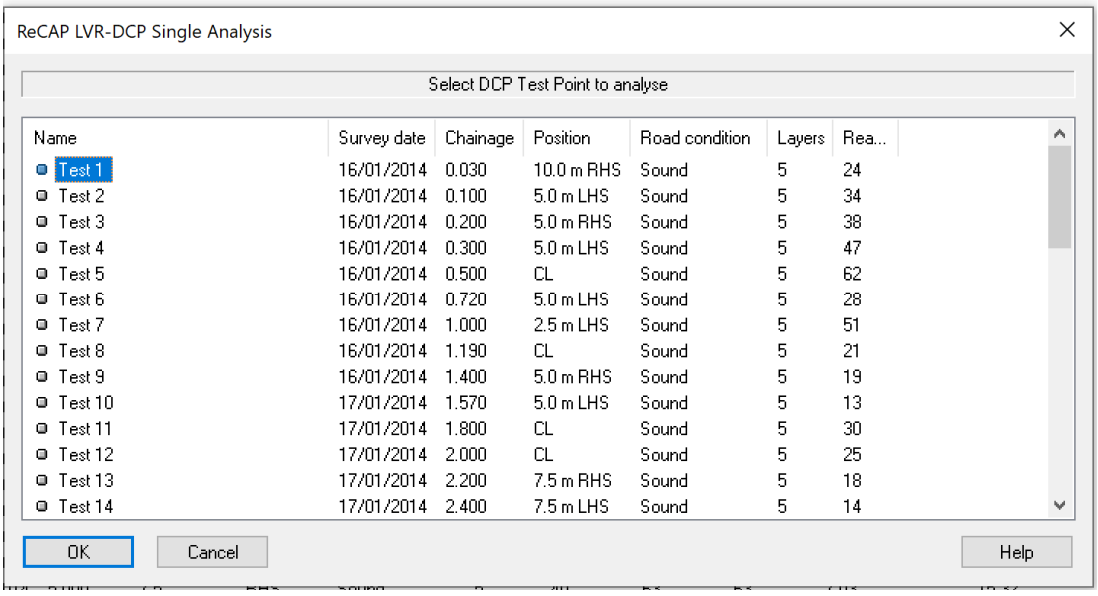


Figure 3-23: Selection of single test point for analysis

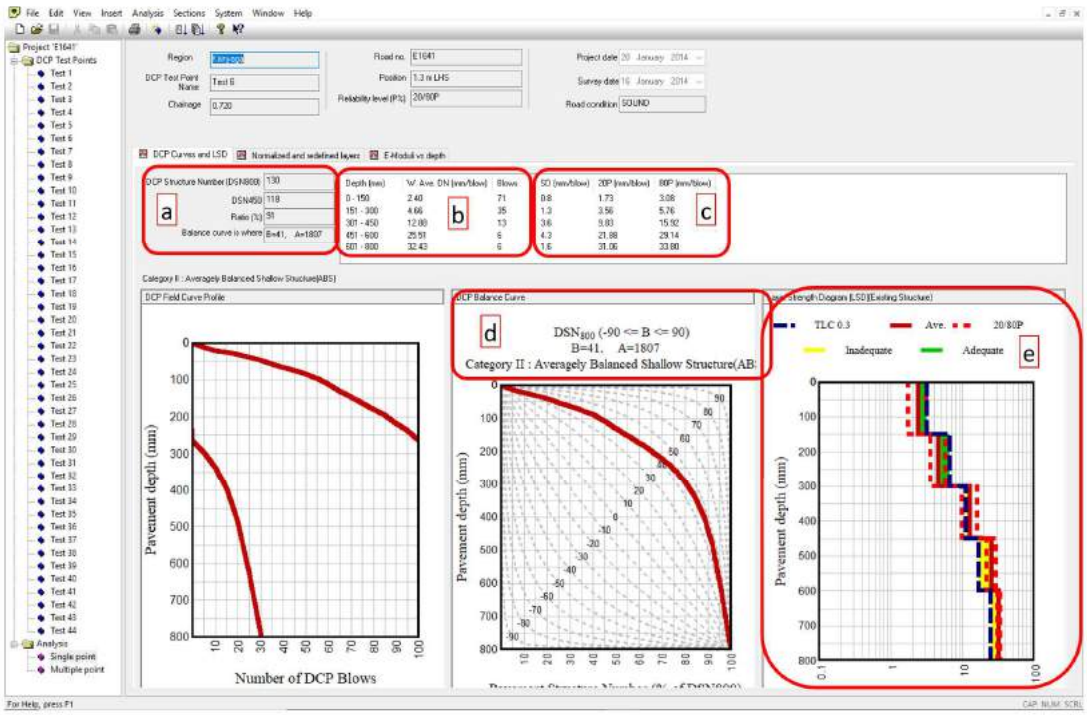


Figure 3-24: Single DCP test point analysis output

The following information is displayed for an immediate interpretation of the in-situ strength of the pavement at that point:

a) Structure Number and pavement balance data:
   - DSN800, DSN450
   - The DSN450/DSN800 ratio, which gives an indication of the balance of the pavement at that point
   - Standard Pavement Balance Curve parameters (see DCP-DN Design Manual)

b) DCP penetration data
   - Weighted average DN values (mm/blow) in the standard layer configuration
   - No of blows to penetrate each layer

c) Statistical analysis of the DCP readings
   - Standard deviation of the DN values in the layer. High SD means high variation, i.e., uneven penetration rate through the layer.
   - Percentile values (only displayed if “Use percentiles/reliability level” is checked in the DCP System settings.

d) Pavement balance classification (see DCP-DN Design Manual)

e) Layer Strength Diagram, in which the following is displayed:
   - Solid red line: Weighted average DN values
   - Dashed dark blue line: Required DCP-DN values as per the DCP-DN design catalogue for the selected Traffic Load Class (TLC).
   - Dotted red lines: Percentile values for each layer. These are only displayed if “Use percentiles/reliability level” is checked in the DCP System settings.
   - Yellow shading: Indicates that the Weighted Average DN for the layer is higher than the catalogue requirement, i.e., the layer in the in-situ condition is too weak.
   - Green shading: Indicates that the Weighted Average DN for the layer is lower than the catalogue requirement, i.e., the layer in the in-situ condition is strong enough.

Both the DCP Field Curve profile, the DCP Balance curve, and the Layer Strength Diagram in this screen can be displayed separately on a larger scale by right-clicking in the respective diagram and selecting "View full screen".

3.4.2 Normalized and redefined layers

By selecting the "Normalized and redefined layers" tab, the following screen is displayed:

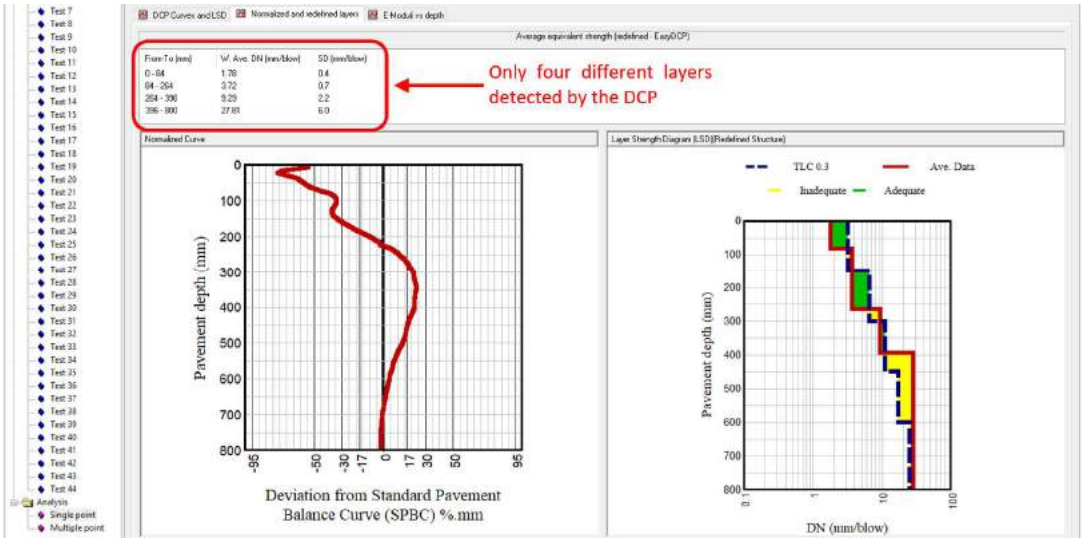


Figure 3-25: Display of Normalized and redefined layers for DCP test point

Figure 3-25 shows the analysis of the same DCP test point, as shown in Figure 3-24, with the crucial difference that here the data are displayed, as "seen" by the DCP, without averaging the readings over the standard 150 mm layer thickness. In this case, the DCP detected only four distinctly different layers. This facilitates the detection of potential weak interlayers in the pavement structure.

Both the standard and normalized Layer Strength Diagrams should be examined during the design process for appropriate decisions, as required.

3.4.3 Multiple point analysis

The procedure for multiple point analysis is similar to the one described above for single points, with the only difference that multiple points can be analysed together, as shown below.

The multiple point analysis function provides the option to analyse selected sections or DCP test points, for instance, on one side of the road.

- Click the "Multiple point analysis" icon or select the select "Multiple point analysis" from the Analysis menu. The screen in Figure 3-26 will be displayed for the selection of points to be analysed.

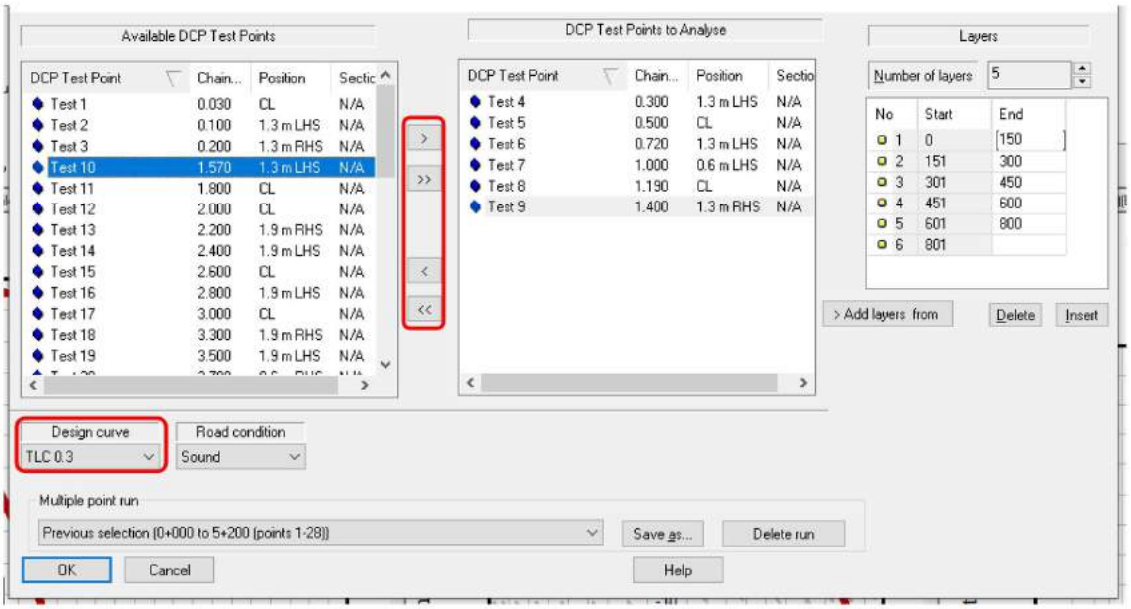


Figure 3-26: Selection of DCP test points for multiple point analysis

- Select points for analysis by using the arrows to move points between the left and middle panel (single arrow moves one point, double arrow moves all points in the respective panel). The points in the middle panel will be analysed together.
- Select the TLC for the analysis.
- Save the analysis with a descriptive name by pressing the "Save as" button.
- Previous analyses can be deleted by pressing the "Delete run" button, if required.
- Click OK.
- The output from the analysis is in the same format as for a single point, as presented in Figure 3-27.

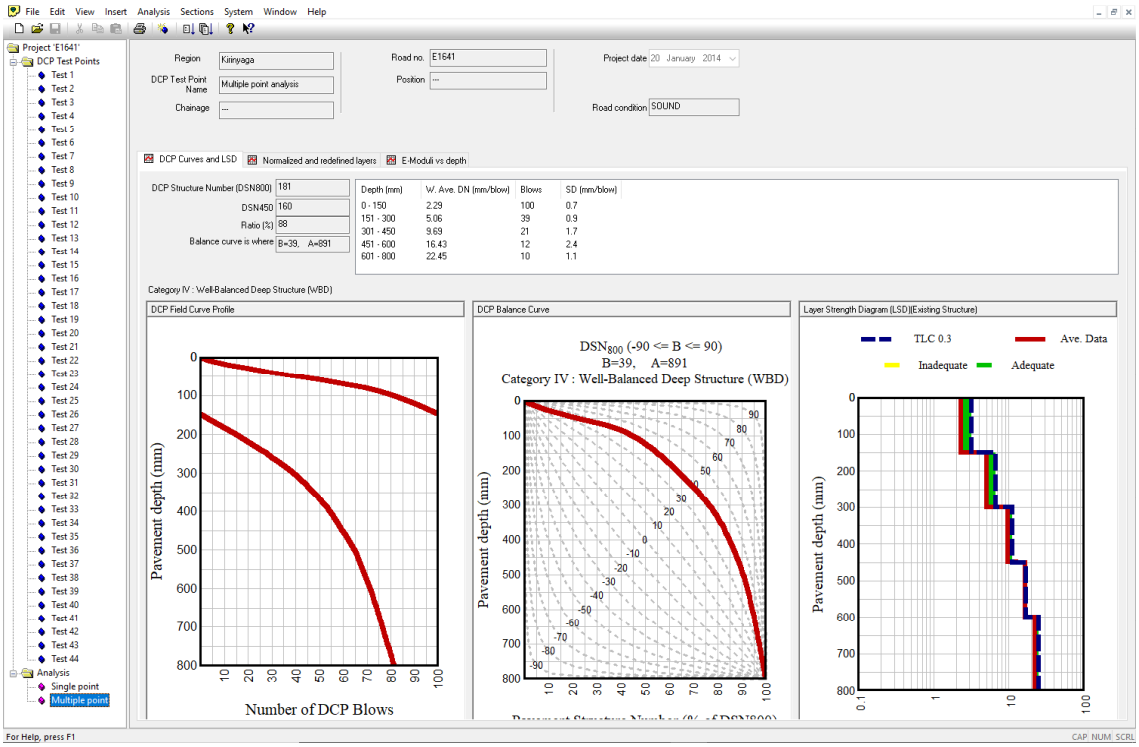


Figure 3-27: Output from multiple point analysis of Points 4-9

3.5 Pavement Design

All the functions for undertaking the pavement design are found under the Sections menu. The procedure is explained in detail below.

3.5.1 Calculate all Properties

For a new project, only the "Calculate all properties" function under the Sections menu is enabled, as shown below. The remaining options in the menu are disabled until this step has been carried out.

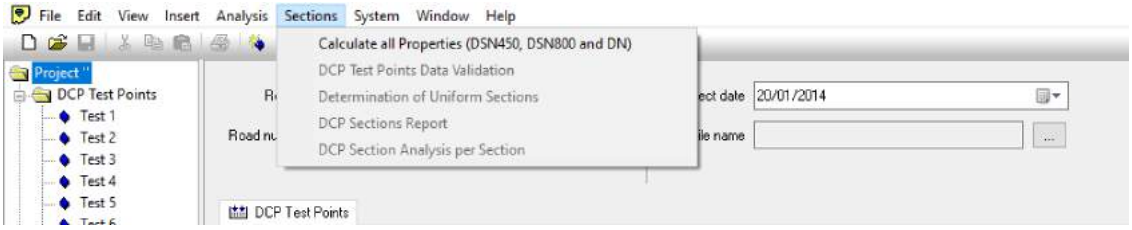


Figure 3-28: "Calculate all properties" menu option

- Select "Calculate all properties".
- Select the TLC for which the DN requirement per layer is compared to the in-situ DN values in the DCP Sections report for the design decisions.
- Select the "Reliability level (P%)" as appropriate for the project. The percentiles of the DN values per layer will then be displayed in the output table. This option is only available if "Use percentiles/reliability level" has been selected in the DCP System configuration (Section 3.2.7). Click OK.

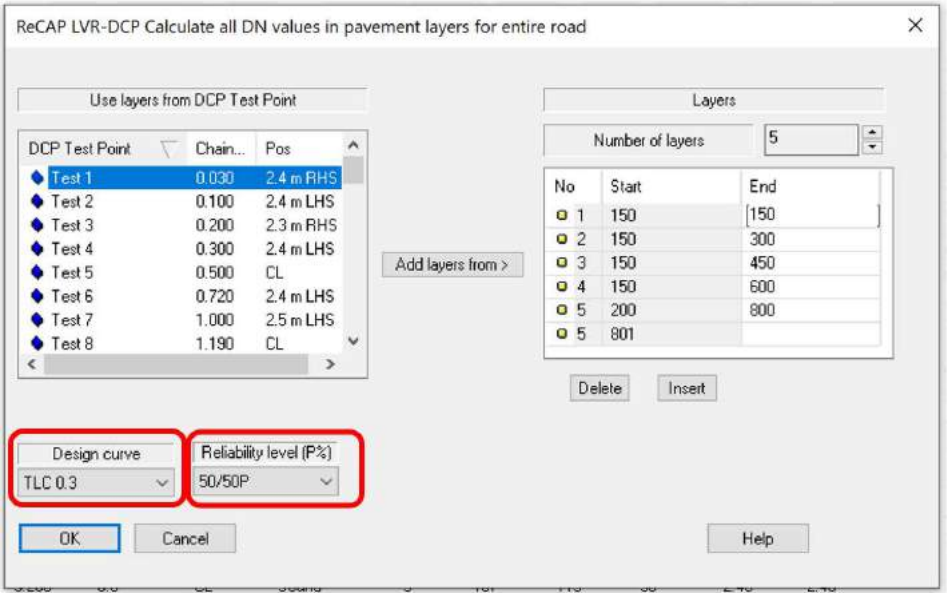


Figure 3-29: Selection of TLC (and percentiles) for "Calculation of all properties"

- As shown in Figure 3-30, the road project is initially set as 1 DCP section

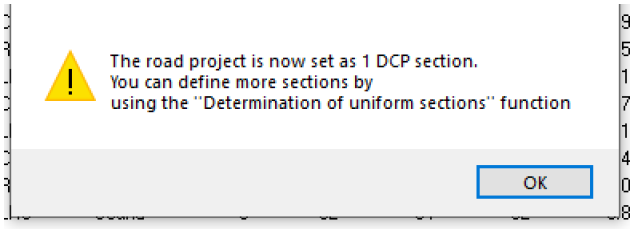
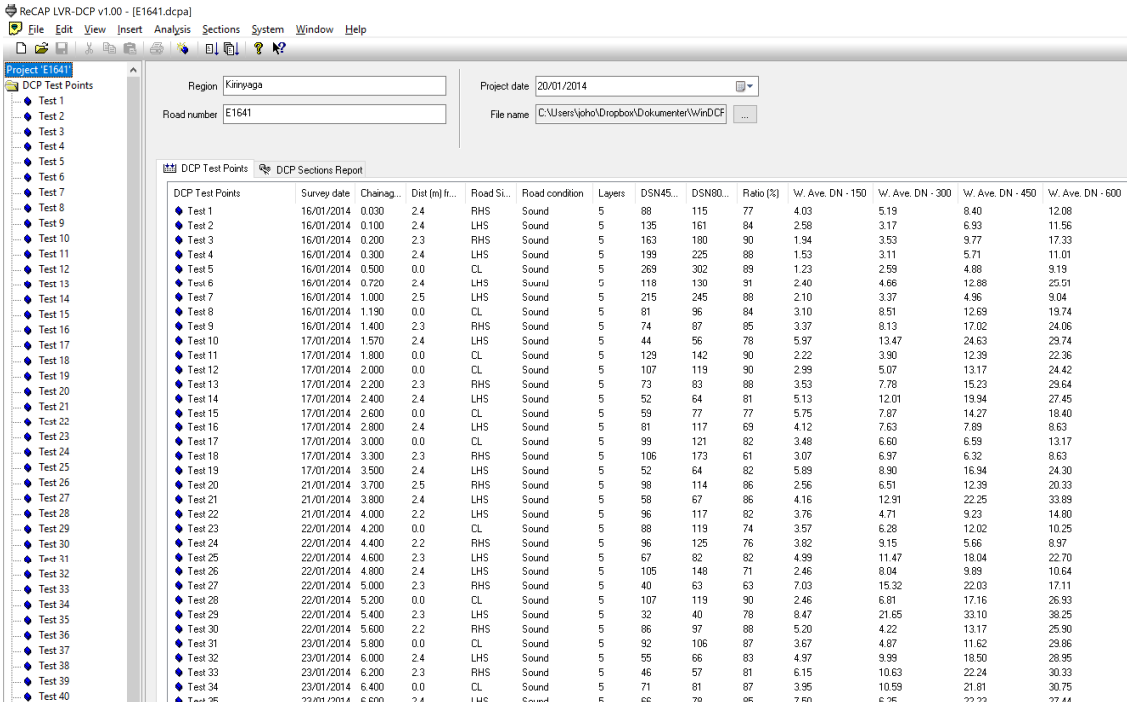


Figure 3-30: Road project set as one section after "Calculation of all properties"

- The output from the calculations (Figure 3-31) can be used to identify “outliers”, i.e., DCP test points with exceptionally high or low DSN and DN values that would distort the calculation of the weighted average values. Such points can be marked as invalid from the right-click menu option.



DCP Test Points	Survey date	Chainag...	Dist (m) fr...	Road Si...	Road condition	Layers	DSN45...	DSN80...	Ratio (%)	W. Ave. DN - 150	W. Ave. DN - 300	W. Ave. DN - 450	W. Ave. DN - 600
Test 1	16/01/2014	0.030	2.4	RHS	Sound	5	88	115	77	4.03	5.19	8.40	12.08
Test 2	16/01/2014	0.100	2.4	LHS	Sound	5	135	161	84	2.58	3.17	6.93	11.56
Test 3	16/01/2014	0.200	2.3	RHS	Sound	5	163	180	90	1.94	3.53	9.77	17.33
Test 4	16/01/2014	0.300	2.4	LHS	Sound	5	199	225	88	1.53	3.11	5.71	11.01
Test 5	16/01/2014	0.500	0.0	CL	Sound	5	269	302	89	1.23	2.59	4.88	9.19
Test 6	16/01/2014	0.720	2.4	LHS	Sound	5	118	130	91	2.40	4.66	12.88	25.01
Test 7	16/01/2014	1.000	2.5	LHS	Sound	5	215	245	88	2.10	3.37	4.96	9.04
Test 8	16/01/2014	1.190	0.0	CL	Sound	5	81	96	84	3.10	8.51	12.69	19.74
Test 9	16/01/2014	1.400	2.3	RHS	Sound	5	74	87	85	3.37	8.13	17.02	24.06
Test 10	17/01/2014	1.570	2.4	LHS	Sound	5	44	56	78	5.97	13.47	24.63	29.74
Test 11	17/01/2014	1.800	0.0	CL	Sound	5	129	142	90	2.22	3.90	12.39	22.36
Test 12	17/01/2014	2.000	0.0	CL	Sound	5	107	119	90	2.99	5.07	13.17	24.42
Test 13	17/01/2014	2.200	2.3	RHS	Sound	5	73	83	88	3.53	7.78	15.23	29.64
Test 14	17/01/2014	2.400	2.4	LHS	Sound	5	52	64	81	5.13	12.01	19.94	27.45
Test 15	17/01/2014	2.600	0.0	CL	Sound	5	59	77	77	5.75	7.87	14.27	18.40
Test 16	17/01/2014	2.800	2.4	LHS	Sound	5	81	117	69	4.12	7.63	7.89	8.63
Test 17	17/01/2014	3.000	0.0	CL	Sound	5	99	121	82	3.48	6.60	6.59	13.17
Test 18	17/01/2014	3.300	2.3	RHS	Sound	5	106	173	61	3.07	6.97	6.32	8.63
Test 19	17/01/2014	3.500	2.4	LHS	Sound	5	52	64	82	5.89	8.90	16.94	24.30
Test 20	21/01/2014	3.700	2.5	RHS	Sound	5	98	114	86	2.56	6.51	12.39	20.33
Test 21	21/01/2014	3.800	2.4	LHS	Sound	5	58	67	86	4.16	12.91	22.25	33.89
Test 22	21/01/2014	4.000	2.2	LHS	Sound	5	96	117	82	3.76	4.71	9.23	14.80
Test 23	22/01/2014	4.200	0.0	CL	Sound	5	88	119	74	3.57	6.28	12.02	10.25
Test 24	22/01/2014	4.400	2.2	RHS	Sound	5	96	125	76	3.82	9.15	5.66	8.97
Test 25	22/01/2014	4.600	2.3	LHS	Sound	5	67	82	82	4.99	11.47	18.04	22.70
Test 26	22/01/2014	4.800	2.4	LHS	Sound	5	105	148	71	2.46	8.04	9.89	10.64
Test 27	22/01/2014	5.000	2.3	RHS	Sound	5	40	63	63	7.03	15.32	22.03	17.11
Test 28	22/01/2014	5.200	0.0	CL	Sound	5	107	119	90	2.46	6.81	17.16	26.93
Test 29	22/01/2014	5.400	2.3	LHS	Sound	5	32	40	79	8.47	21.65	33.10	38.25
Test 30	22/01/2014	5.600	2.2	RHS	Sound	5	86	97	88	5.20	4.22	13.17	25.90
Test 31	23/01/2014	5.800	0.0	CL	Sound	5	92	106	87	3.67	4.87	11.62	29.86
Test 32	23/01/2014	6.000	2.4	LHS	Sound	5	55	66	83	4.97	9.99	18.50	28.95
Test 33	23/01/2014	6.200	2.3	RHS	Sound	5	46	57	81	6.15	10.63	22.24	30.33
Test 34	23/01/2014	6.400	0.0	CL	Sound	5	71	81	87	3.95	10.59	21.81	30.75

Figure 3-31: Output table from "Calculation of all properties" function

3.5.2 DCP Test Points Data Validation

This presents various views of the DCP data and the in-situ layers as detected by the DCP (Figure 3-32) and has no influence on the design.

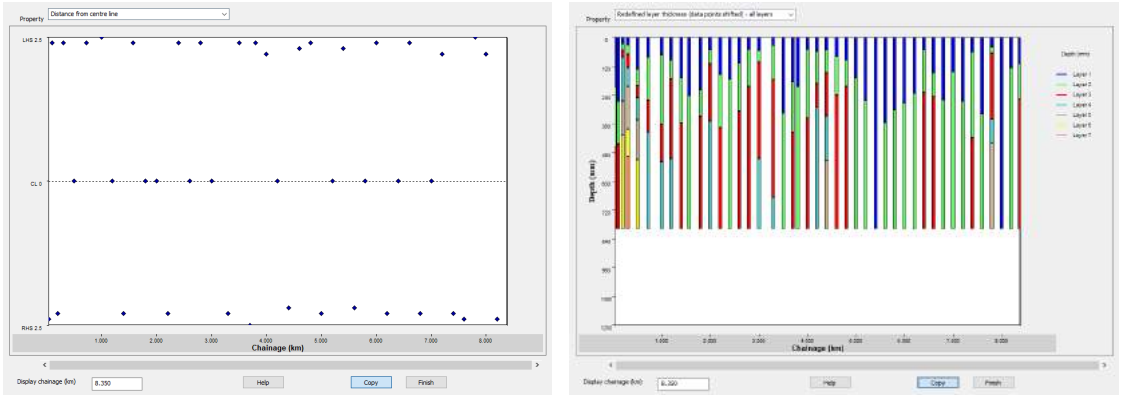


Figure 3-32: Position of DCP test points and Number of redefined layers

3.5.3 Determination of Uniform Sections

Uniform sections are determined using a Cumulative Sum (Cusum) analysis of the DN and DSN values for all DCP test points. Uniform section delimiters are set where the Cusum curves, as displayed in Figure 3-33, change their general direction. These points may not always coincide with all the curves, so one has to decide which ones to prioritise. The DSN_{450} is normally ranked before the DSN_{800} Cusum, and similarly, the DN Cusums for the 0-150 mm and 150-300 mm layers are ranked before the 300-450 mm layer Cusum.

Minor changes should be disregarded.

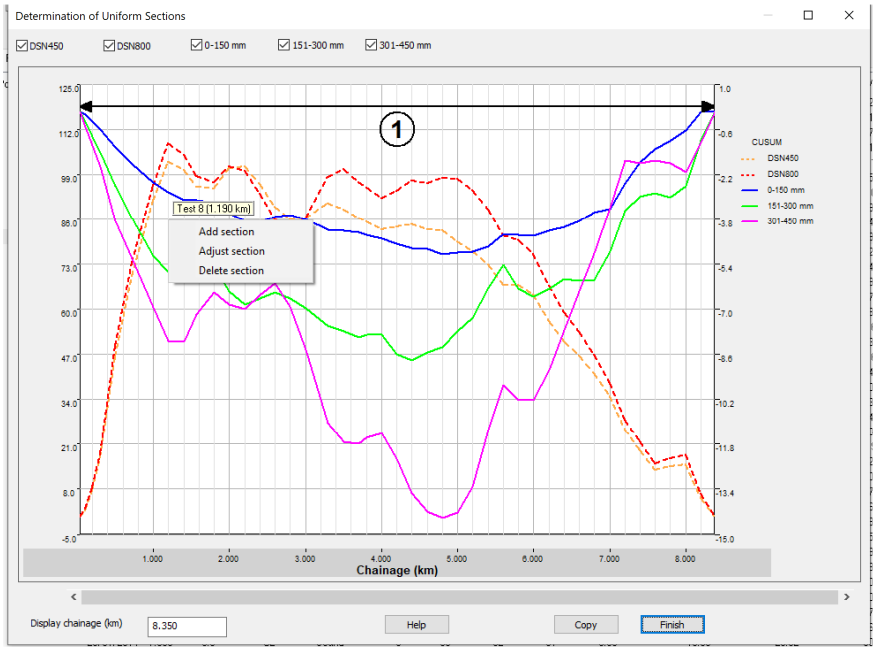


Figure 3-33: Project initially set as one section

The procedure to determine uniform sections is as follows:

- Select which of the Cusum curves to display with the tick-boxes above the curves. By default, all five curves are selected.
- Hover the cursor over the diagram and right-click to bring up the menu, as shown.
- Select which action to perform.
- For "Add section", click where there is a general change of direction of the curves and confirm by clicking the "Yes" button when prompted.
- The section delimiter will automatically "snap" to the nearest DCP test point chainage and can later be adjusted to a different chainage or deleted, as required.
- In this example, four uniform sections have been identified. Click finish.
- The sections will now be displayed in the DCP Sections report for separate analysis and pavement design.

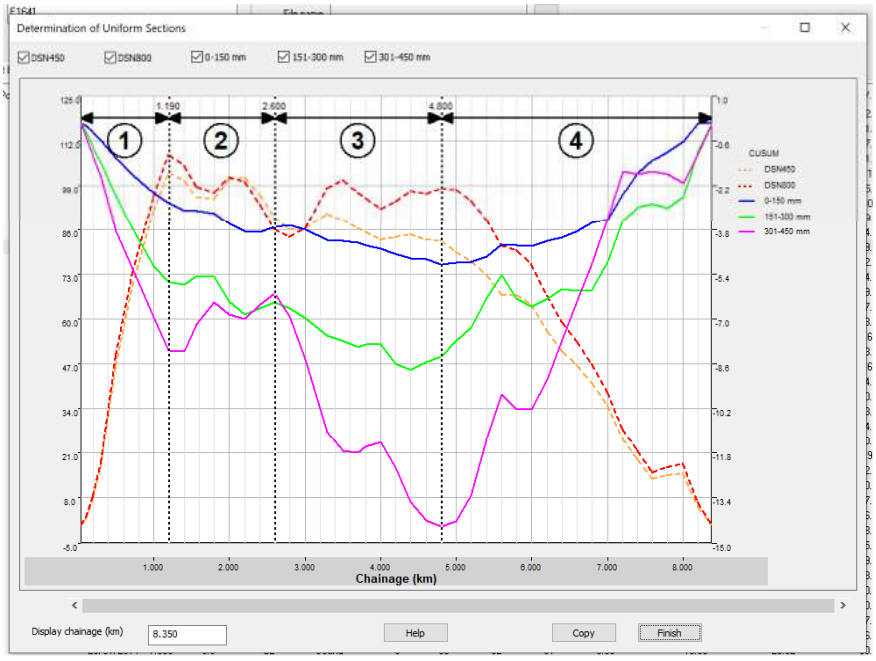
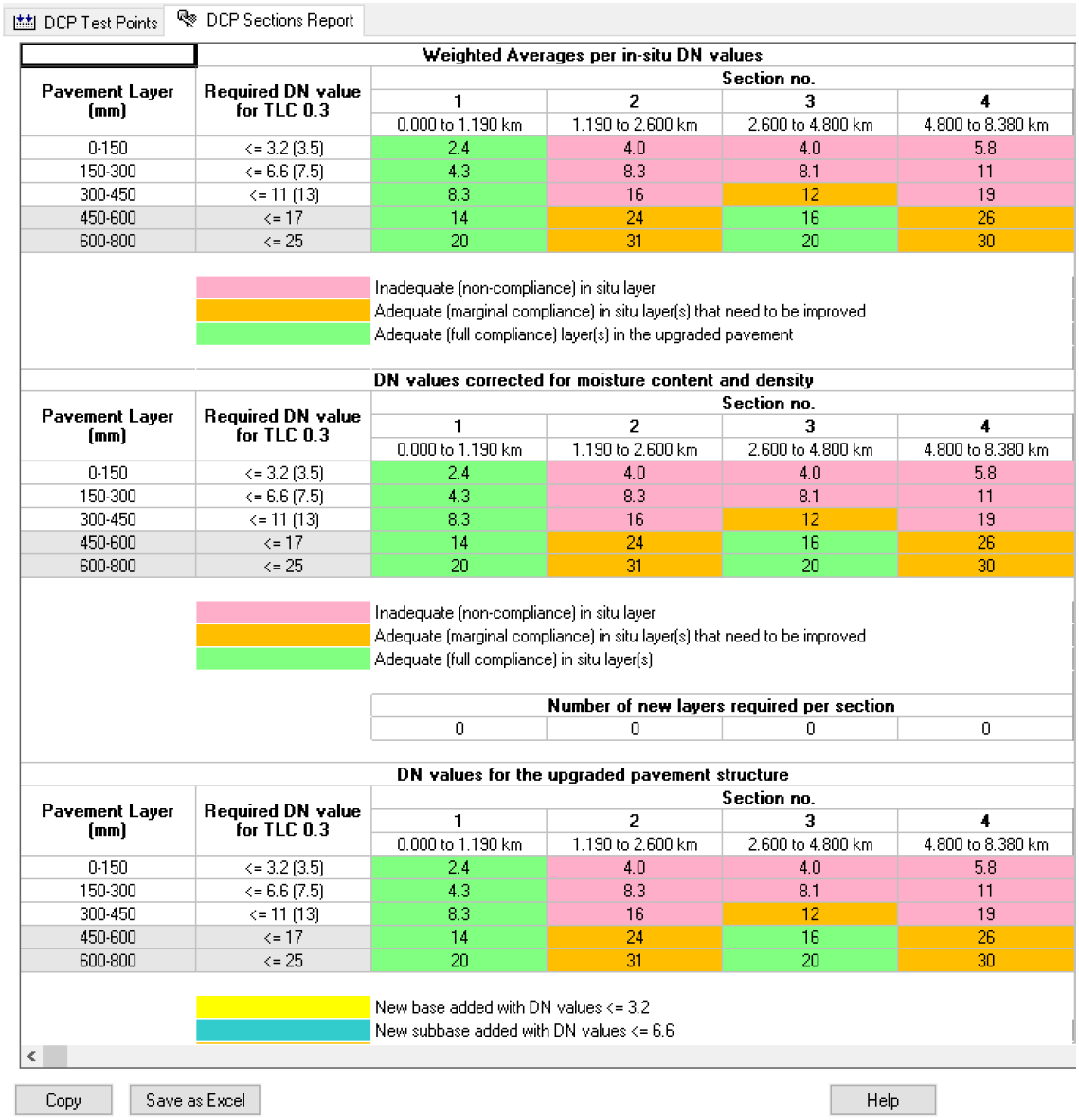


Figure 3-34: Determination of uniform sections

3.5.4 DPC Sections Report

The DCP Sections Report is displayed by clicking the "DCP Sections Report" tab, as shown below.



DCP Test Points | DCP Sections Report

Weighted Averages per in-situ DN values

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4	4.0	4.0	5.8
150-300	<= 6.6 (7.5)	4.3	8.3	8.1	11
300-450	<= 11 (13)	8.3	16	12	19
450-600	<= 17	14	24	16	26
600-800	<= 25	20	31	20	30

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) layer(s) in the upgraded pavement

DN values corrected for moisture content and density

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4	4.0	4.0	5.8
150-300	<= 6.6 (7.5)	4.3	8.3	8.1	11
300-450	<= 11 (13)	8.3	16	12	19
450-600	<= 17	14	24	16	26
600-800	<= 25	20	31	20	30

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) in situ layer(s)

Number of new layers required per section			
0	0	0	0

DN values for the upgraded pavement structure

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4	4.0	4.0	5.8
150-300	<= 6.6 (7.5)	4.3	8.3	8.1	11
300-450	<= 11 (13)	8.3	16	12	19
450-600	<= 17	14	24	16	26
600-800	<= 25	20	31	20	30

New base added with DN values <= 3.2
New subbase added with DN values <= 6.6

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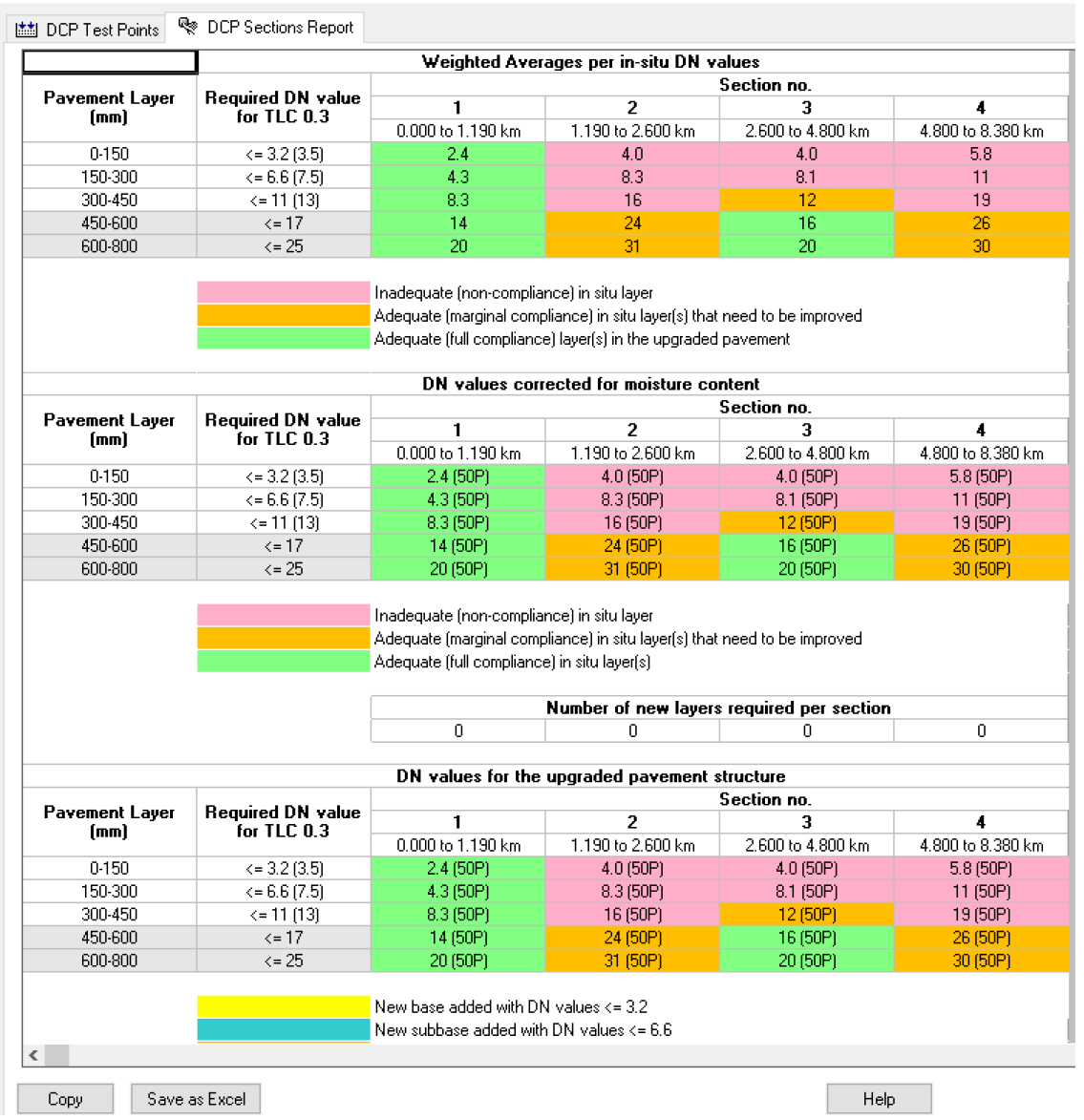
Figure 3-35: DCP Sections Report

By selecting "Use percentiles/reliability level" from the DCP System settings menu, the report will display the percentiles (defaulting to the 50th percentile) in the middle and bottom tables, as shown below.



DCP Test Points | DCP Sections Report

Weighted Averages per in-situ DN values

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4	4.0	4.0	5.8
150-300	<= 6.6 (7.5)	4.3	8.3	8.1	11
300-450	<= 11 (13)	8.3	16	12	19
450-600	<= 17	14	24	16	26
600-800	<= 25	20	31	20	30

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) layer(s) in the upgraded pavement

DN values corrected for moisture content

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4 (50P)	4.0 (50P)	4.0 (50P)	5.8 (50P)
150-300	<= 6.6 (7.5)	4.3 (50P)	8.3 (50P)	8.1 (50P)	11 (50P)
300-450	<= 11 (13)	8.3 (50P)	16 (50P)	12 (50P)	19 (50P)
450-600	<= 17	14 (50P)	24 (50P)	16 (50P)	26 (50P)
600-800	<= 25	20 (50P)	31 (50P)	20 (50P)	30 (50P)

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) in situ layer(s)

Number of new layers required per section			
0	0	0	0

DN values for the upgraded pavement structure

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4 (50P)	4.0 (50P)	4.0 (50P)	5.8 (50P)
150-300	<= 6.6 (7.5)	4.3 (50P)	8.3 (50P)	8.1 (50P)	11 (50P)
300-450	<= 11 (13)	8.3 (50P)	16 (50P)	12 (50P)	19 (50P)
450-600	<= 17	14 (50P)	24 (50P)	16 (50P)	26 (50P)
600-800	<= 25	20 (50P)	31 (50P)	20 (50P)	30 (50P)

New base added with DN values <= 3.2
New subbase added with DN values <= 6.6

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Figure 3-36: DCP Sections Report with percentiles

Pavement design

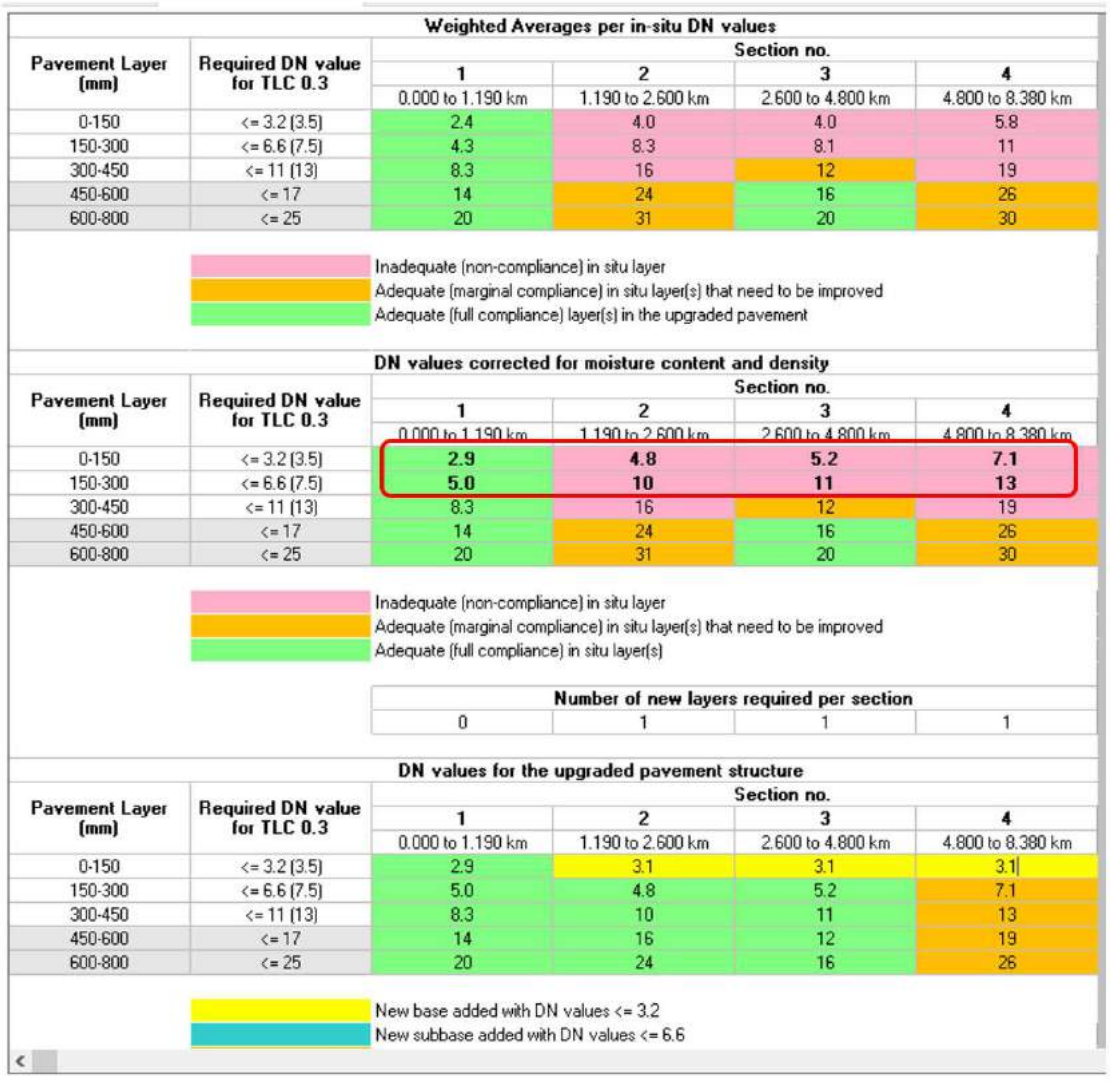
The program provides for the use of two different methods for the pavement design, as follows:

Option 1 (recommended): Based on laboratory testing of the in-situ layers to determine the DN values at the anticipated long-term in-service equilibrium moisture content (EMC) and field density after construction.

Option 2: Based on the determination of representative FMC/OMC ratios of the materials in the in-situ layers and an engineering judgement of the likelihood of the long-term in-service FMC/OMC ratio increasing, remaining about the same or decreasing after upgrading and improvement of the drainage as compared to the ratio at the time of the DCP survey. This option may be used where it is likely that the in-situ FMC/OMC ratio is fairly constant within the uniform sections, for instance, for a reasonably shaped gravel road with adequate and functional drainage.

For Option 1:

- Enter laboratory DN values determined at the anticipated long-term in-service EMC and field density in the middle table. In this case, new values for the two top layers have been entered.
- Compare the DN values in the middle table with the requirements of the DCP-DN catalogue for the selected TLC and determine the number of layers to be added for each uniform section.
- The layers in the bottom table are then moved down in steps corresponding to the number of layers to be added and changes colour automatically ("Green" for adequate, "Amber" for marginal compliance) as shown.
- Laboratory DN values for the borrow pit material to be used for the new base and subbase are entered in the empty (yellow or blue) cells provided.
- Section 4 is only marginally compliant. Engineering judgment will have to be applied to decide whether to:
    - Accept the design, as shown (increased risk).
    - Import another layer (expensive).
    - Modify the in-situ material (mechanically or chemically) and rework the layers (increased cost).



Weighted Averages per in-situ DN values

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4	4.0	4.0	5.8
150-300	<= 6.6 (7.5)	4.3	8.3	8.1	11
300-450	<= 11 (13)	8.3	16	12	19
450-600	<= 17	14	24	16	26
600-800	<= 25	20	31	20	30

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) layer(s) in the upgraded pavement

DN values corrected for moisture content and density

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	**2.9**	**4.8**	**5.2**	**7.1**
150-300	<= 6.6 (7.5)	**5.0**	**10**	**11**	**13**
300-450	<= 11 (13)	8.3	16	12	19
450-600	<= 17	14	24	16	26
600-800	<= 25	20	31	20	30

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) in situ layer(s)

Number of new layers required per section			
0	1	1	1

DN values for the upgraded pavement structure

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.9	3.1	3.1	3.1
150-300	<= 6.6 (7.5)	5.0	4.8	5.2	7.1
300-450	<= 11 (13)	8.3	10	11	13
450-600	<= 17	14	16	12	19
600-800	<= 25	20	24	16	26

New base added with DN values <= 3.2
New subbase added with DN values <= 6.6

Figure 3-37: Pavement design based on laboratory DN tests of in-situ layers

For Option 2:

- Assess the likelihood of the pavement becoming wetter, remaining about the same or drying out after upgrading and improvement of the drainage and select the appropriate percentile value for design:
    - FMC/OMC ratio increases: Select 80th percentile
    - FMC/OMC ration about the same: Select 50th percentile
    - FMC/OMC ratio decreases: Select 20th percentile

  The 80/20 percentiles are normally considered adequate for LVRs, but other percentiles may be used for an increased margin of safety.
- In this case, based on the assessment that the anticipated long-term in-service FMC/OMC ratio is likely to be higher than the in-situ FMC/OMC ratio at the time of the DCP survey, the 80th percentile of the DN values for the two upper layers are used for the design (i.e., these layers are likely to become wetter in-service).
- The percentile values are selected by clicking in the respective cells in the middle table, as shown below:

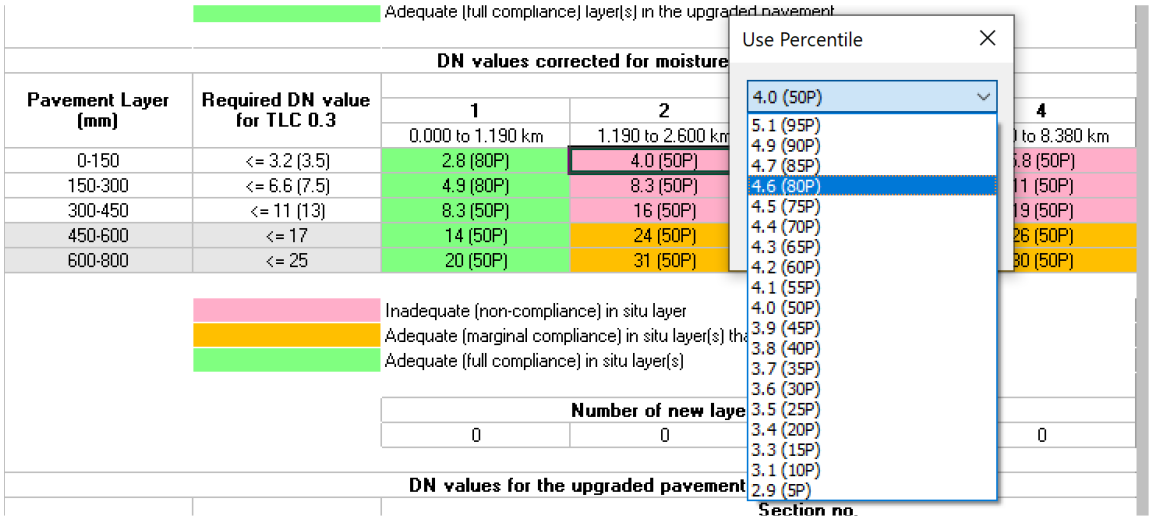


Figure 3-38: Selection of DN percentile values

- After selecting the percentiles, compare the DN values in the middle table with the requirements of the DCP-DN catalogue for the selected TLC and determine the number of layers to be added for each uniform section.
- The layers in the bottom table are then moved down in steps corresponding to the number of layers to be added and changes colour automatically ("Green" for adequate, "Amber" for marginal compliance) as shown.
- Laboratory DN values for the borrow pit material to be used for the new base and subbase are entered in the empty (yellow or blue) cells provided.
- Section 4 is only marginally compliant. Engineering judgment will have to be applied to decide whether to:
    - Accept the design, as shown (increased risk).
    - Import another layer (expensive).
    - Modify the in-situ material (mechanically or chemically) and rework the layers (increased cost).

DCP Test Points | DCP Sections Report

Weighted Averages per in-situ DN values

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.4	4.0	4.0	5.8
150-300	<= 6.6 (7.5)	4.3	8.3	8.1	11
300-450	<= 11 (13)	8.3	16	12	19
450-600	<= 17	14	24	16	26
600-800	<= 25	20	31	20	30

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) layer(s) in the upgraded pavement

DN values corrected for moisture content

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.8 (80P)	4.6 (80P)	4.8 (80P)	6.6 (80P)
150-300	<= 6.6 (7.5)	4.9 (80P)	9.9 (80P)	9.7 (80P)	13 (80P)
300-450	<= 11 (13)	8.3 (50P)	16 (50P)	12 (50P)	19 (50P)
450-600	<= 17	14 (50P)	24 (50P)	16 (50P)	26 (50P)
600-800	<= 25	20 (50P)	31 (50P)	20 (50P)	30 (50P)

Inadequate (non-compliance) in situ layer
Adequate (marginal compliance) in situ layer(s) that need to be improved
Adequate (full compliance) in situ layer(s)

Number of new layers required per section			
0	1	1	1

DN values for the upgraded pavement structure

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no. 1 (0.000 to 1.190 km)	2 (1.190 to 2.600 km)	3 (2.600 to 4.800 km)	4 (4.800 to 8.380 km)
0-150	<= 3.2 (3.5)	2.8 (80P)	3.1	3.1	3.1
150-300	<= 6.6 (7.5)	4.9 (80P)	4.6 (80P)	4.8 (80P)	6.6 (80P)
300-450	<= 11 (13)	8.3 (50P)	9.9 (80P)	9.7 (80P)	13 (80P)
450-600	<= 17	14 (50P)	16 (50P)	12 (50P)	19 (50P)
600-800	<= 25	20 (50P)	24 (50P)	16 (50P)	26 (50P)

New base added with DN values <= 3.2
New subbase added with DN values <= 6.6

Figure 3-39: Pavement design based on DN percentile values

3.5.5 DCP Section Analysis per Section

After completing the design, each section can be analysed separately, as shown:

- Select the "DCP Section Analysis per Section" from the Sections menu.
- Select the section to be analysed and whether to analyse the existing or upgraded structure. Click OK.

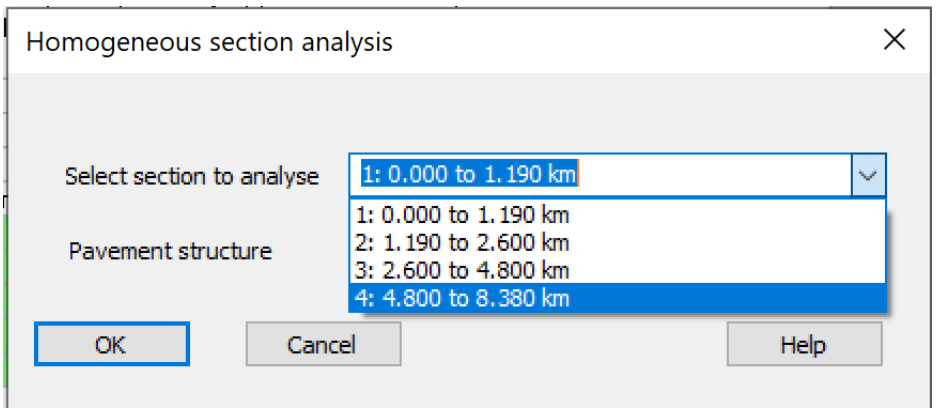


Figure 3-40: Selection of Homogeneous (uniform) Section for analysis

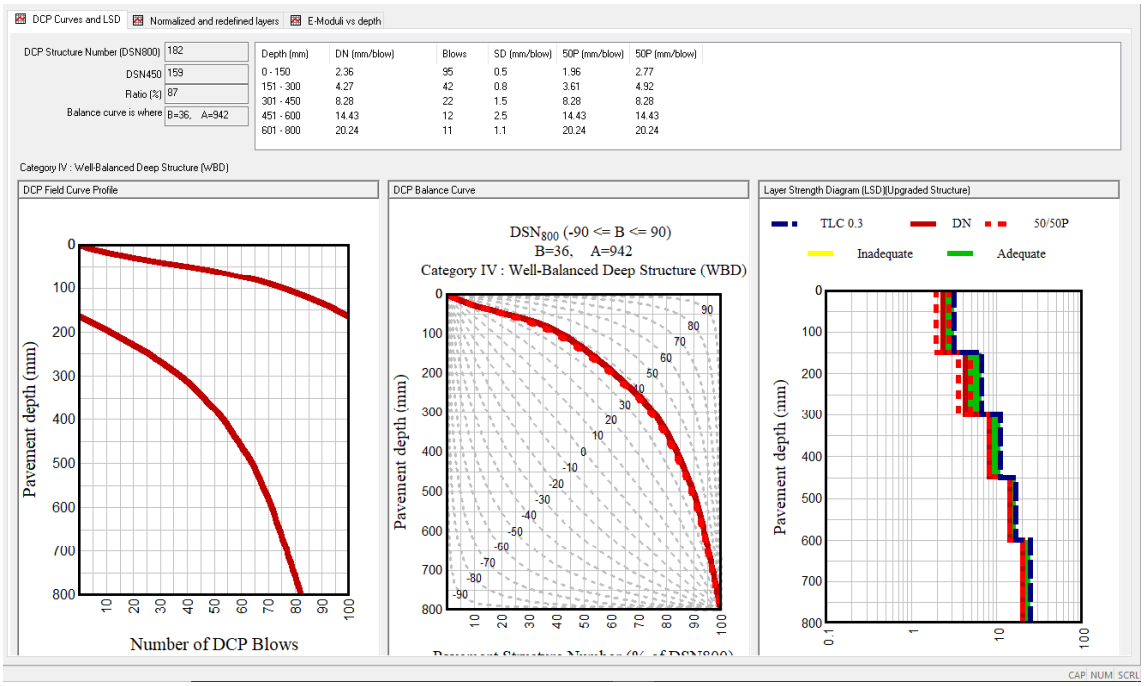


Figure 3-41: Output from analysis of Homogeneous Section 4

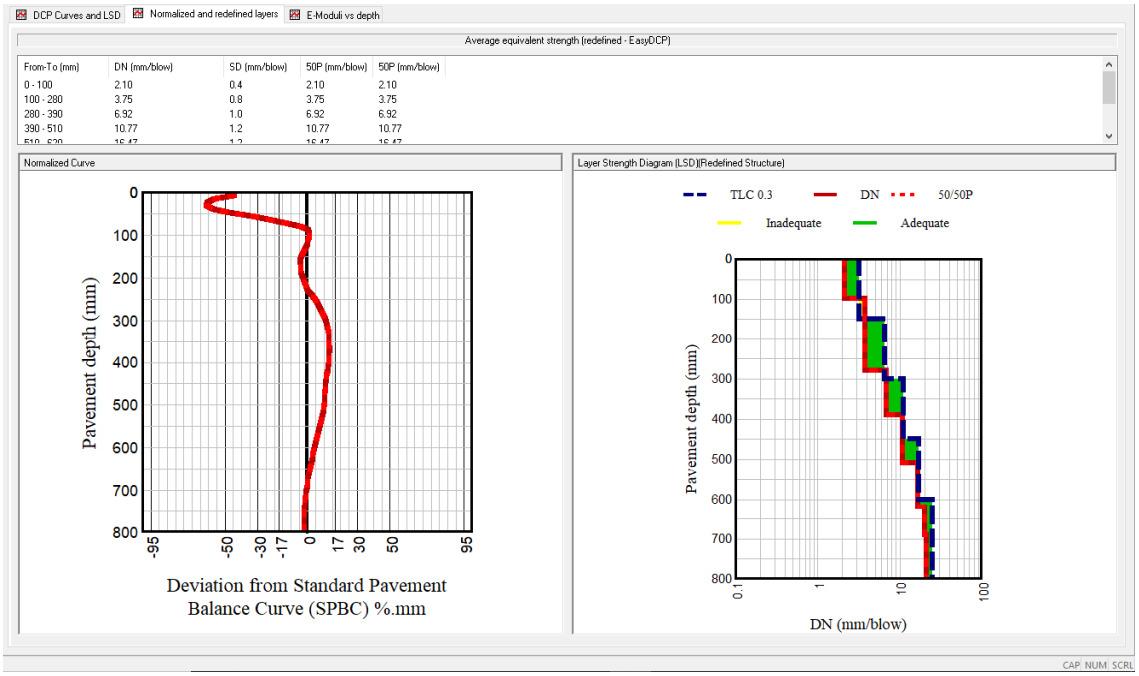


Figure 3-42: Normalised and redefined layers for Homogeneous Section 4

3.5.6 Saving separate sections for further analysis

In the above example, further analysis of Uniform Section 4 may be warranted, since it was only marginally compliant and is fairly long (3.580 km). A more detailed analysis may thus enable an optimisation of the design for that section.

The section can be saved under a separate name with the "Save DCP Test Points in Selected DCP Section as…" option in the File menu, as shown below.

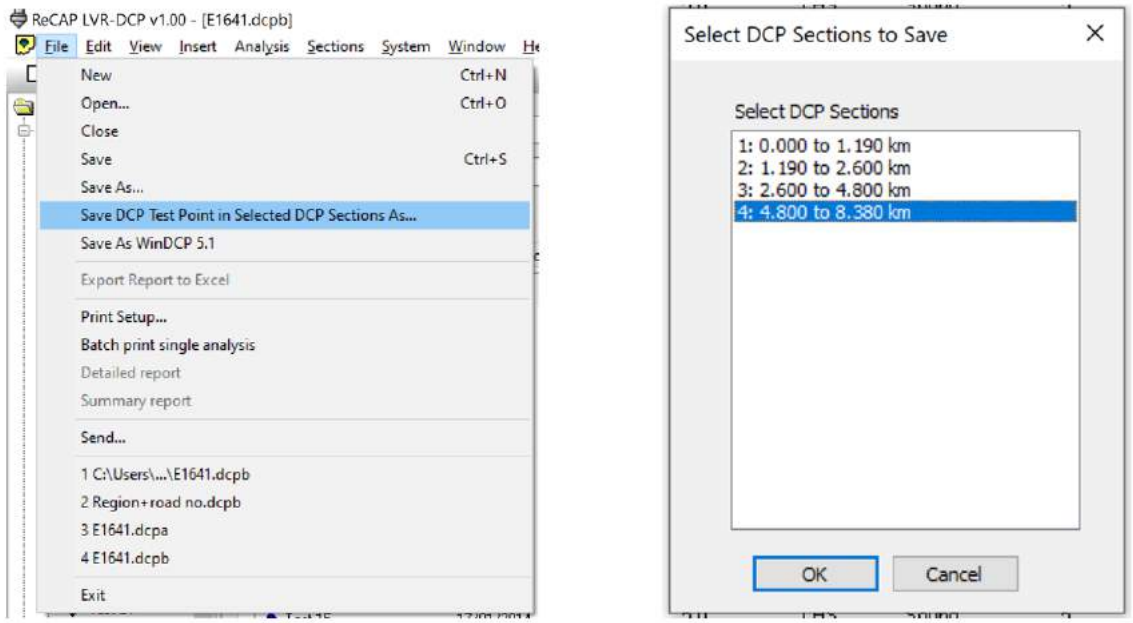


Figure 3-43: Selecting uniform section for separate analysis

The analysis of the section is carried out in the same manner as described above.

3.6 Report Options

Reporting options are available in the File menu, as shown below.

3.6.1 Report for Single DCP Test Points

The procedure to create a report is as follows:

- Select "Batch print single analysis".
- Select "Detailed" or "Summary" report.
    - The "Detailed report" will contain all the information and analysis of the selected test point.
    - The "Summary report" will summarise the most important information for the selected test point.

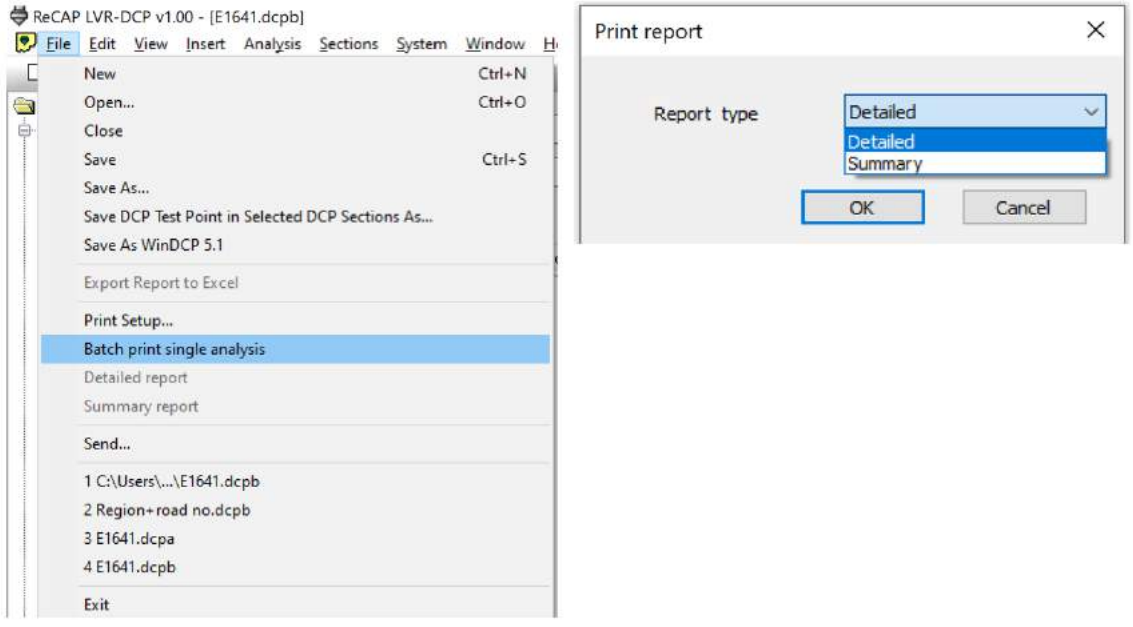


Figure 3-44: Selection of report option

- Select the DCP test point and the printer. Click OK.

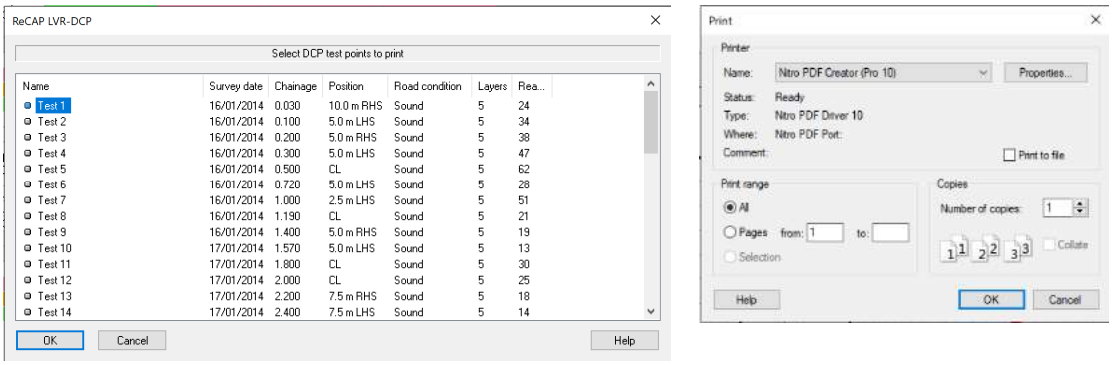


Figure 3-45: Selection of DCP Test Point for the report and printer to be used

- The "Detailed" and "Summary" report options in the File menu are then enabled for showing the reports on-screen.

3.6.2 Reports for Uniform Sections

This option will generate reports for each uniform section which can be appended to the Project Design Report. The procedure is as follows:

- Select "DCP Section Analysis per Section" in the Sections menu.

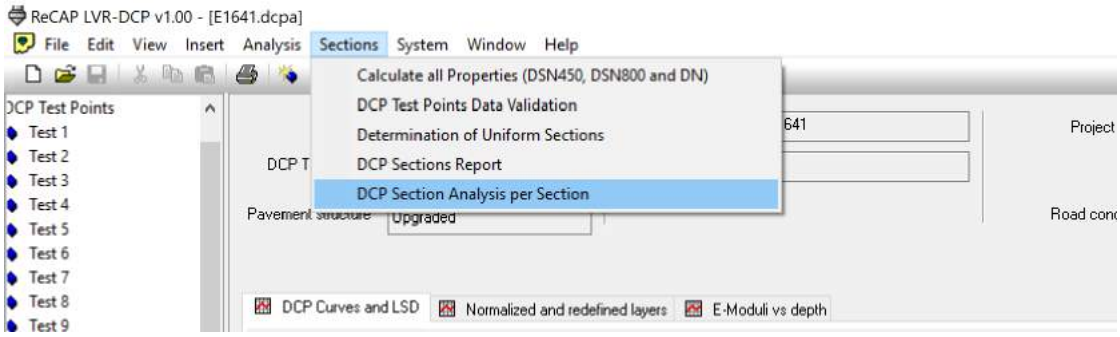


Figure 3-46: Menu option for "DCP Section Analysis per Section"

- Then select which section to analyse and whether to analyse the existing or upgraded pavement structure, as shown blow.

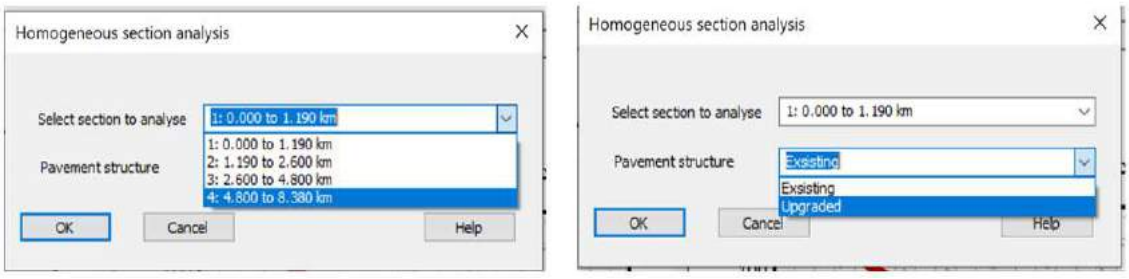


Figure 3-47: Selection of Uniform Section and pavement structure for analysis

- The output screen for analysis of the upgrade pavement structure for Section 4 is shown in Figure 3-48 below.

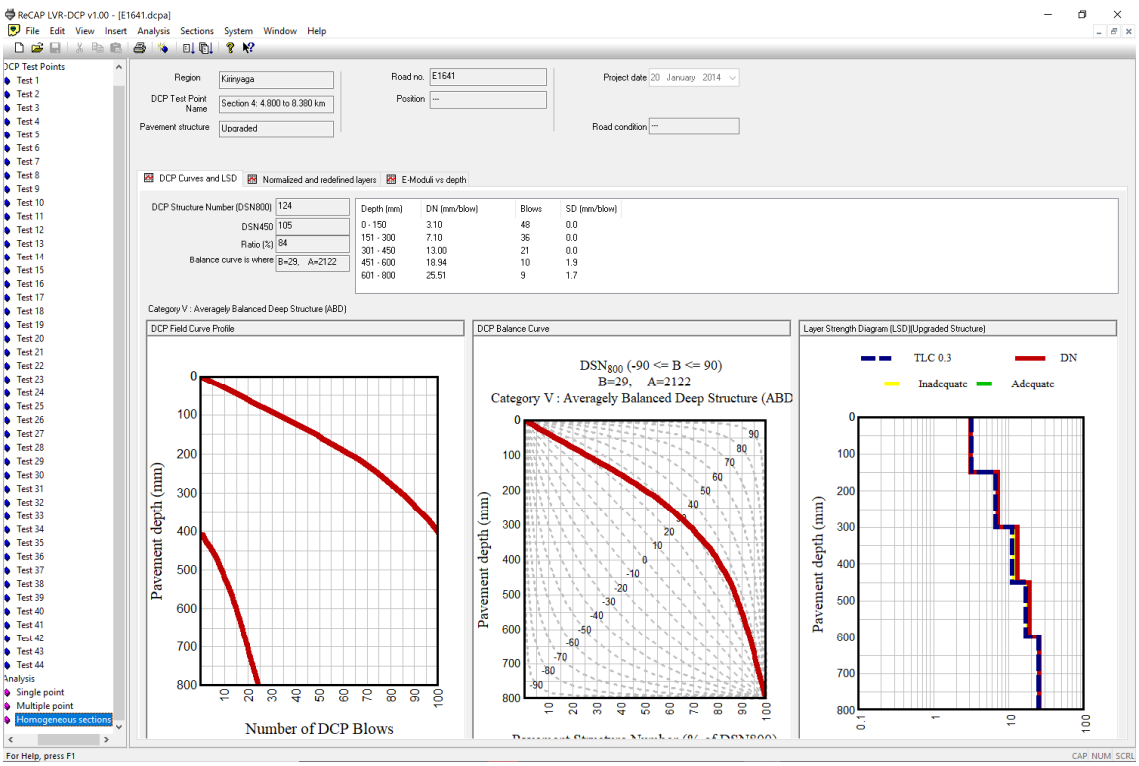


Figure 3-48: Output screen for the analysis of Uniform Section 4

- From the file menu, select either "Detailed" or "Summary" Report to generate the reports shown in Figure 3-49 to 3-52.

DCP Detailed Report - Section 4: 4.800 to 8.380 km, Upgraded Pavement Structure

Project Date: 20 January, 2014 **Region:** Kirinyaga
Analysis Date: 01 October, 2020 **Road Number:** E1641

DCP test points included in analysis

DCP Test Points:	Survey date	Position	Chainage (km)	Condition
Test 26	22 January 2014	2.4 m LHS	4.800	Sound
Test 27	22 January 2014	2.3 m RHS	5.000	Sound
Test 28	22 January 2014	CL	5.200	Sound
Test 29	22 January 2014	2.3 m LHS	5.400	Sound
Test 30	22 January 2014	2.2 m RHS	5.600	Sound
Test 31	23 January 2014	CL	5.800	Sound
Test 32	23 January 2014	2.4 m LHS	6.000	Sound
Test 33	23 January 2014	2.3 m RHS	6.200	Sound
Test 34	23 January 2014	CL	6.400	Sound
Test 35	23 January 2014	2.4 m LHS	6.600	Sound
Test 36	23 January 2014	2.3 m RHS	6.800	Sound
Test 37	23 January 2014	CL	7.000	Sound
Test 38	23 January 2014	2.2 m LHS	7.200	Sound
Test 39	24 January 2014	2.3 m RHS	7.400	Sound
Test 40	24 January 2014	2.4 m RHS	7.600	Sound
Test 41	24 January 2014	2.5 m LHS	7.800	Sound
Test 42	24 January 2014	2.2 m LHS	8.000	Sound
Test 43	24 January 2014	2.4 m RHS	8.200	Sound
Test 44	24 January 2014	2.3 m LHS	8.380	Sound

DCP Structure Number (DSN_{800}) (Blows): 124
DCP Structure Number (DSN_{450}) (Blows): 105
Ratio-(DSN_{450}/DSN_{800}) (%) 84
Multiple Point Run: Section 4: 4.800 to 8.380 km
Standard Pavement Balance Curve (SPBC): B=29, A=2122
Category V : Averagely Balanced Deep Structure (ABD)

BN_{100}-Data (%): 25.9
Traffic Loading Class (TLC): TLC 0.3

Average equivalent strength (Upgraded Pavement Structure)

Depth (mm)	DN (mm / blow)	SD (mm / blow)	Blows	Ave. E-Moduli (MPa)
0 - 150	3.10	0.0	48	336
151 - 300	7.10	0.0	36	139
301 - 450	13.00	0.0	21	73
451 - 600	18.94	1.9	10	49
601 - 800	25.51	1.7	9	36

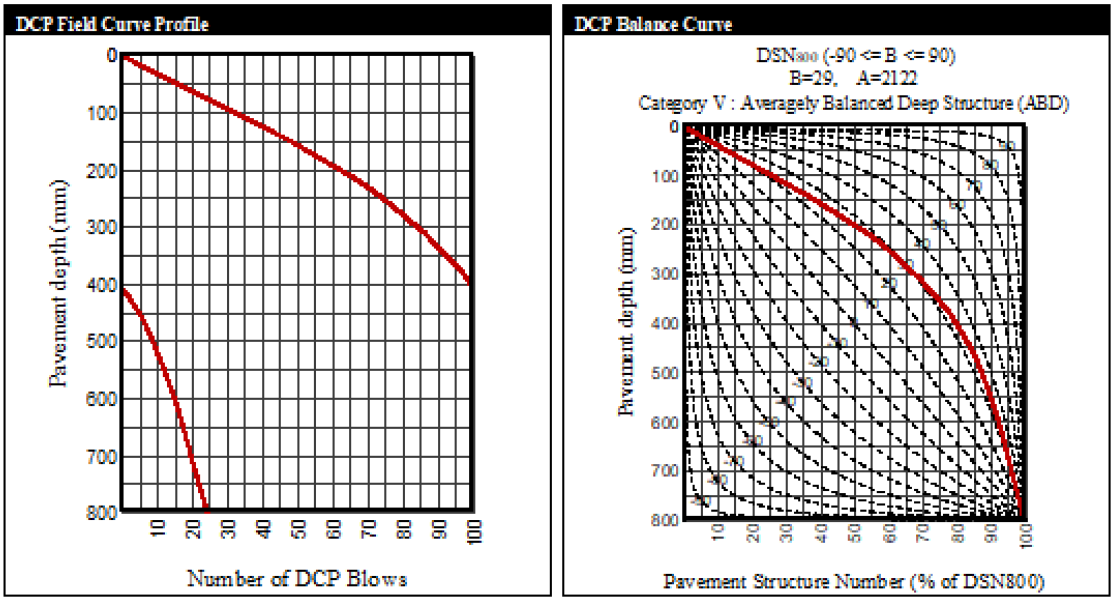
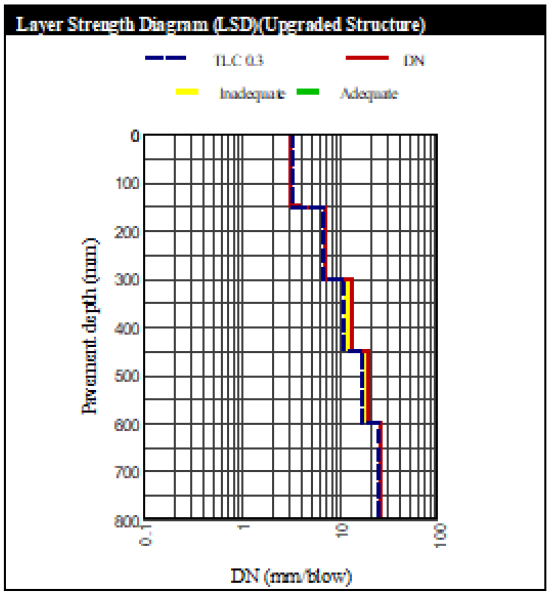
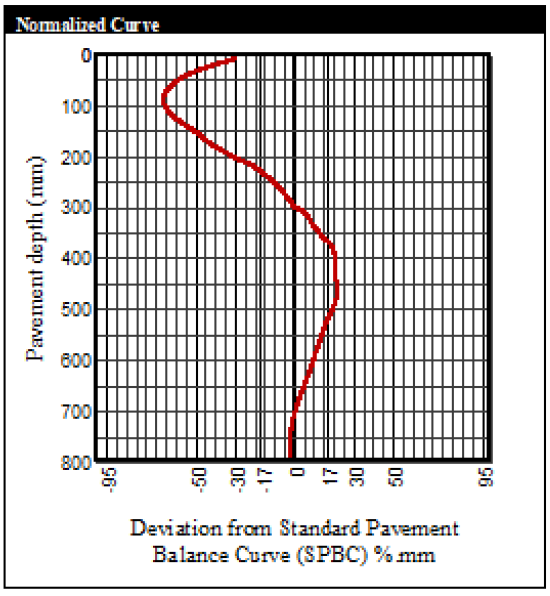


Figure 3-49: Detailed report, page 1



Average equivalent strength (Redefined-EasyDCP Pavement Structure)

Depth (mm)	DN (mm / blow)	SD (mm / blow)	Blows	Ave E-Moduli (MPa)
0 - 150	3.10	0.0	48	336
150 - 220	4.95	0.3	20	204
220 - 310	6.69	0.7	18	148
310 - 380	9.40	0.8	11	103
380 - 460	13.59	1.1	9	70
460 - 610	19.39	1.8	10	48
610 - 800	26.21	1.5	9	35



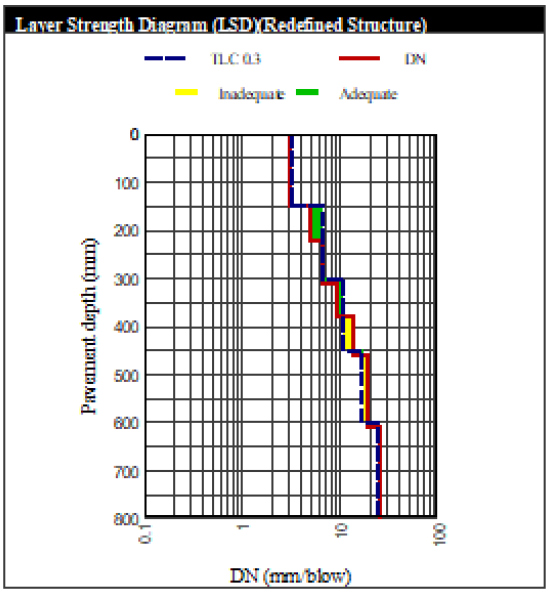


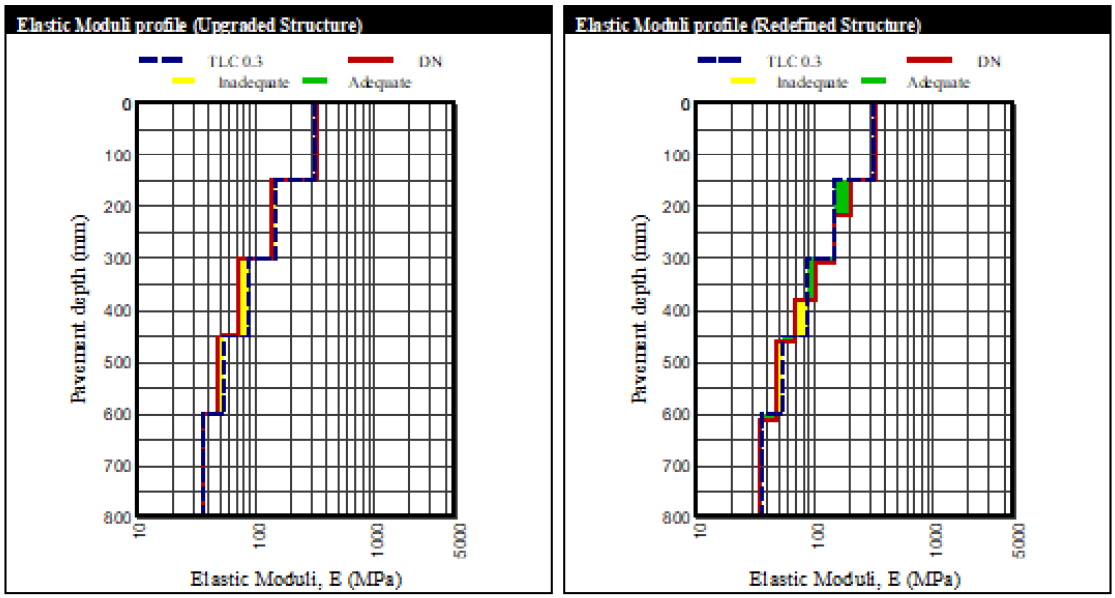
Figure 3-50: Detailed report, page 2

E-Moduli (MPa) and Layer Strength Diagram (Upgraded Pavement Structure)

Depth (mm)	Ave. E-Moduli (MPa)
0 - 150	336
151 - 300	139
301 - 450	73
451 - 600	49
601 - 800	36

E-Moduli (MPa) and Layer Strength Diagram (Redefined EasyDCP Pavement Structure)

Depth (mm)	Ave. E-Moduli (MPa)
0 - 150	336
150 - 220	204
220 - 310	148
310 - 380	103
380 - 460	70
460 - 610	48
610 - 800	35



Summary of + and - Areas (Curve fitting table -Upgraded structure)

Depth (mm)	Cumulative Area (% mm), A
0 - 296	-1429
297 - 704	674
705 - 792	-19
Absolute Area	2122

Figure 3-51: Detailed Report, page 3

DCP Summary Report - Section 4: 4.800 to 8.380 km, Upgraded Pavement Structure

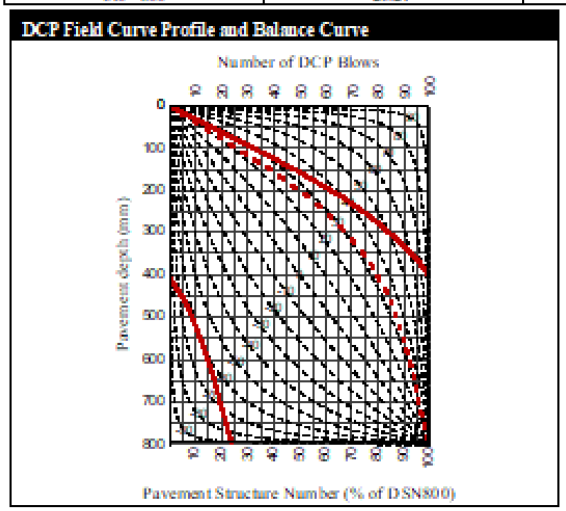
Project Date:	20 January, 2014	**Region:**	Kirinyaga
Analysis Date:	01 October, 2020	**Road Number:**	E1641
DCP Structure Number (DSN800) (Blows):	124	**BN100-Data (%):**	25.9
DCP Structure Number (DSN450) (Blows):	105	**Traffic Loading Class (TLC):**	TLC 0.3
Ratio-(DSN450/DSN800) (%)	84		
Multiple Point Run:	Section 4: 4.800 to 8.380 km		
Standard Pavement Balance Curve (SPBC):	B=29, A=2122		
Category V : Averagely Balanced Deep Structure (ABD)			

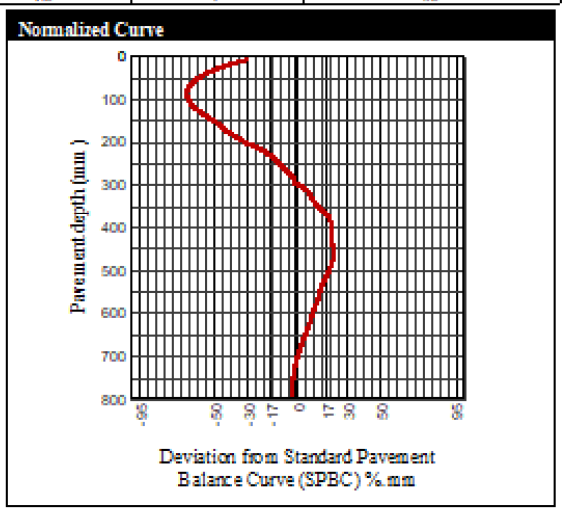
Average equivalent strength (Upgraded Pavement Structure)

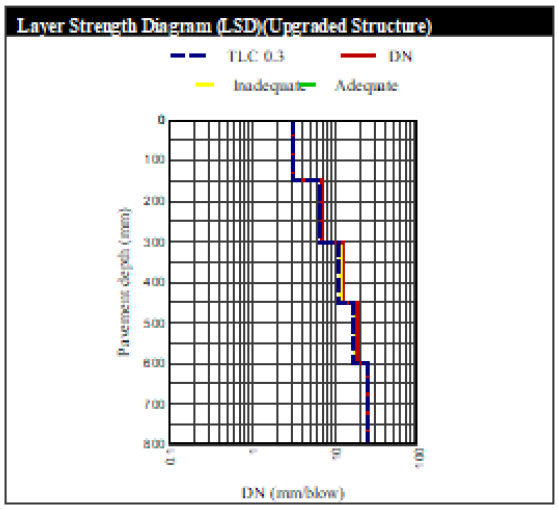
Depth (mm)	DN (mm / blow)	SD (mm / blow)	Blows	Ave. E-Moduli (MPa)
0 - 150	3.10	0.0	48	336
151 - 300	7.10	0.0	36	139
301 - 450	13.00	0.0	21	73
451 - 600	18.94	1.9	10	49
601 - 800	25.51	1.7	9	36

Average equivalent strength (Redefined-EasyDCP Pavement Structure)

Depth (mm)	DN (mm / blow)	SD (mm / blow)	Blows	Ave. E-Moduli (MPa)
0 - 150	3.10	0.0	48	336
150 - 220	4.95	0.3	20	204
220 - 310	6.69	0.7	18	148
310 - 380	9.40	0.8	11	103
380 - 460	13.59	1.1	9	70
460 - 610	19.39	1.8	10	48
610 - 800	26.21	1.5	9	35







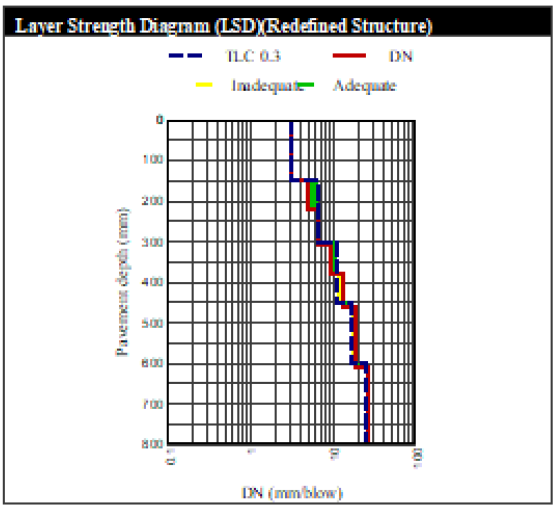


Figure 3-52: Summary report

4. Laboratory projects

4.1 Starting and new project (File menu)

Select "Create new project" from the opening screen and then "Laboratory" for starting a new laboratory project, as shown below.

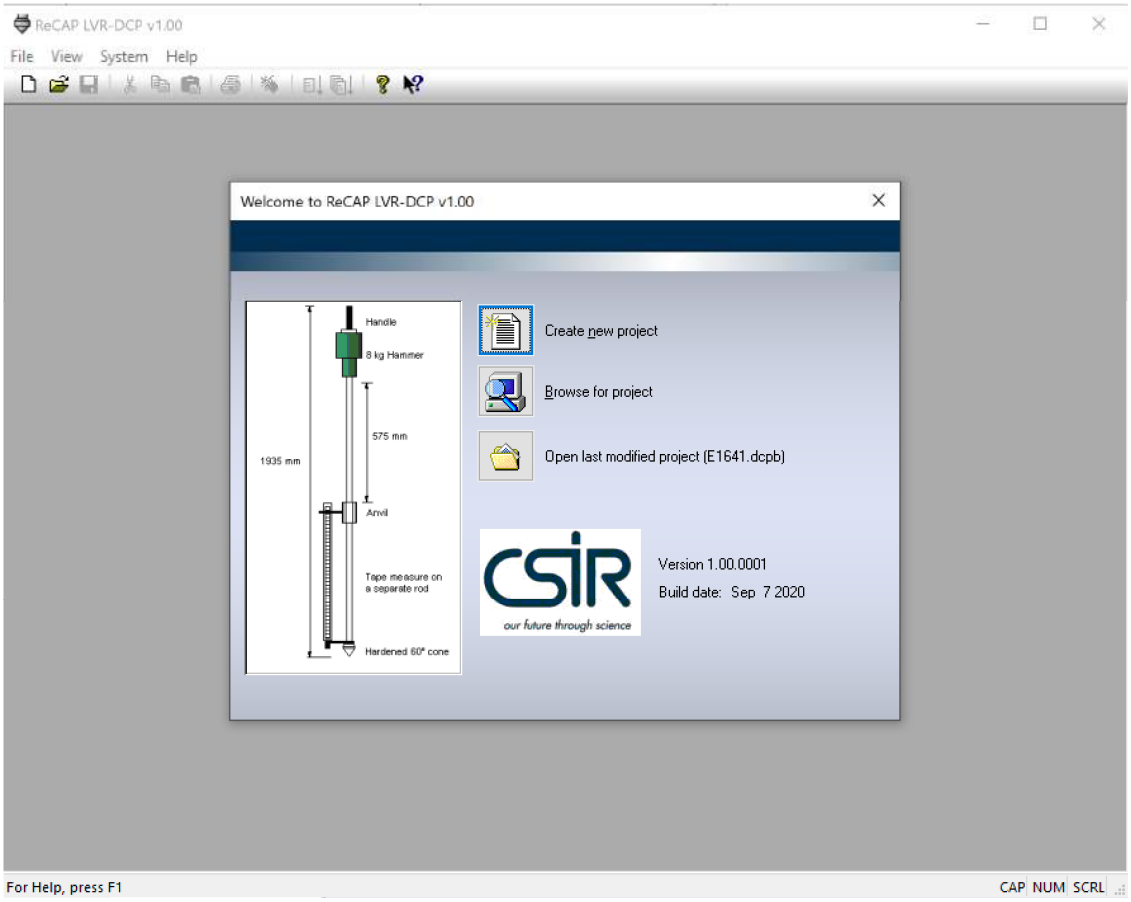


Figure 4-1: Opening screen

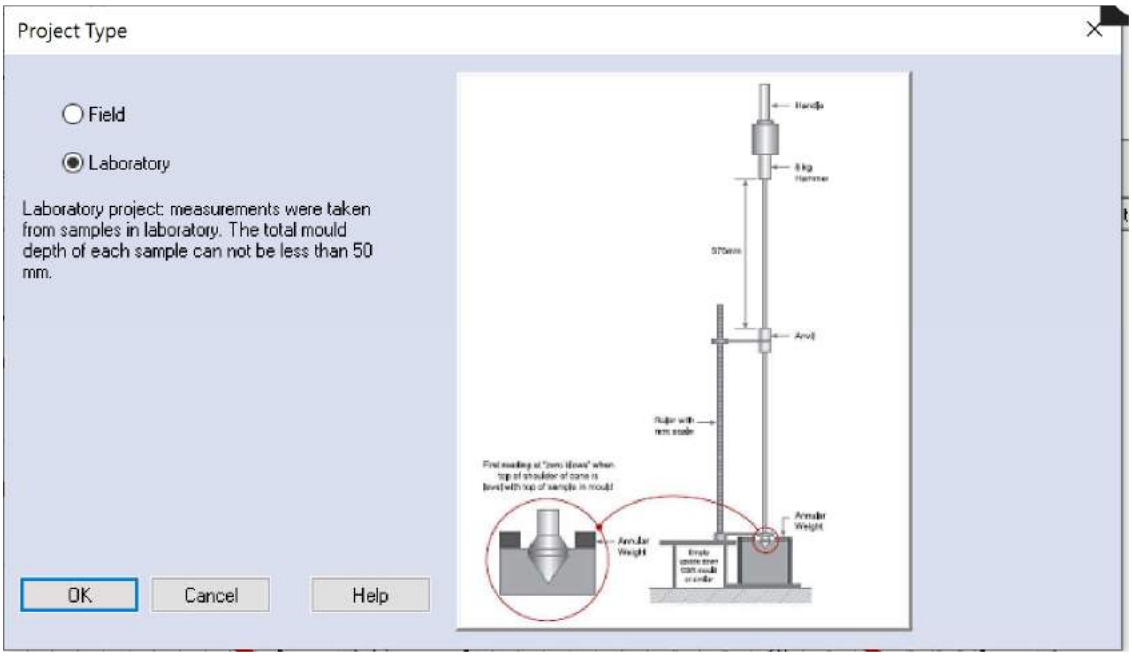


Figure 4-2: Selection of laboratory project

Define and save the project file:

- Assign a Job Reference for clear project identification.
- Save the file in the common DCP project folder.

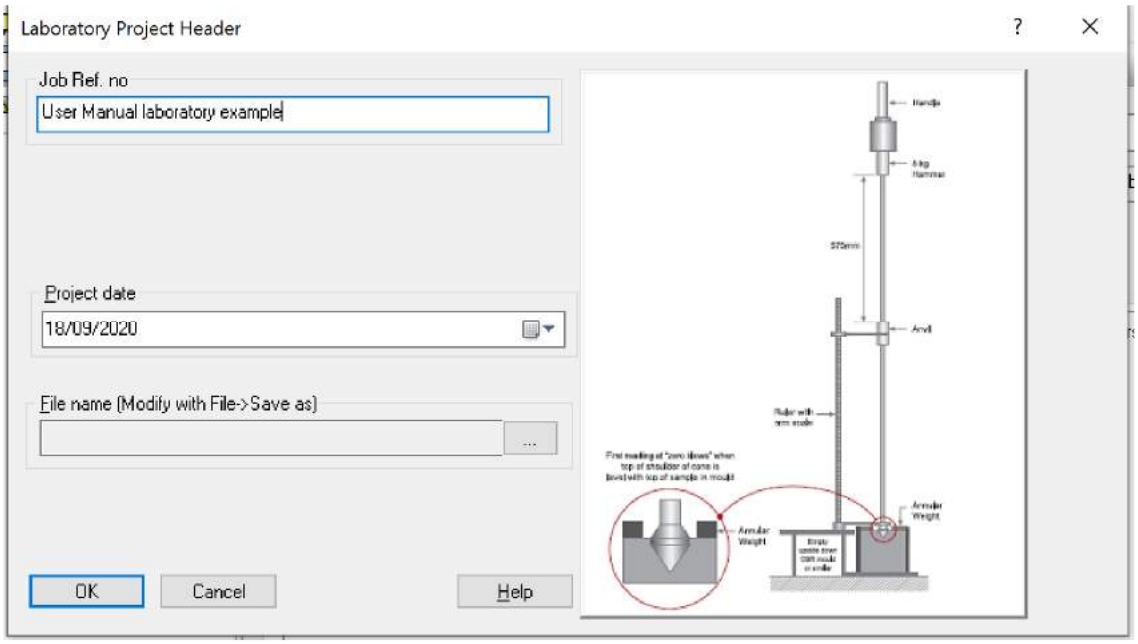


Figure 4-3: Assign Job Reference

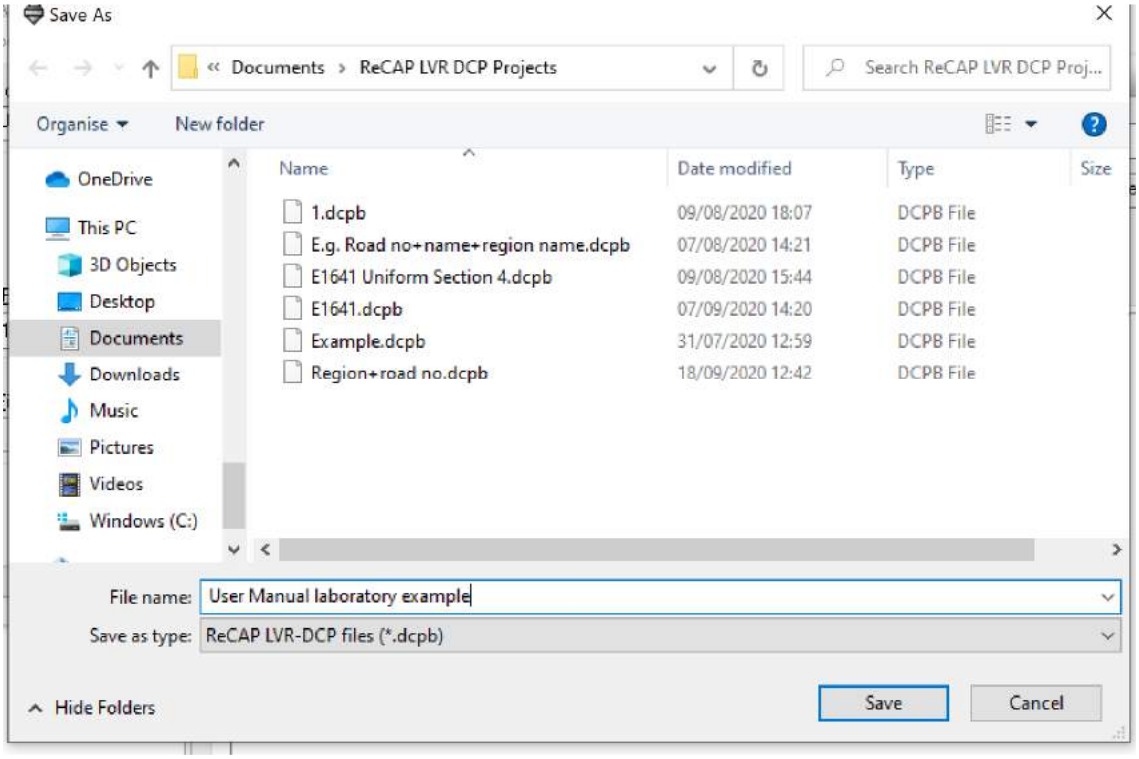


Figure 4-4: Save file in DCP project folder

- Saving the file brings up the main data entry screen in Figure 4-5.

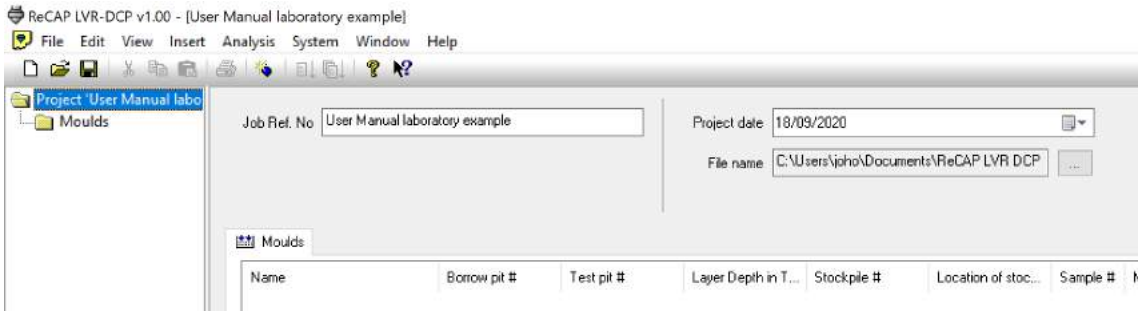


Figure 4-5: Main data entry screen

4.2 Menu options

The menu options are similar to the ones for the field project, with some differences, as shown below.

4.2.1 Insert

Inserts a new mould for entering laboratory test data. This option is also available from the short-cut icon.

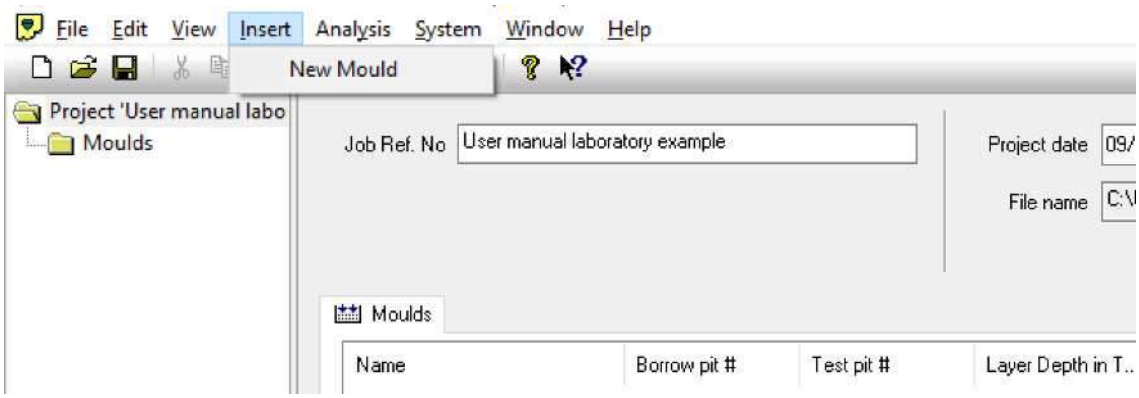


Figure 4-6: Insert menu

4.2.2 Analysis

Provides options for "Single" and "Multiple" mould analysis as well as for "Calculation of all properties". These options are disabled until test data have been entered.

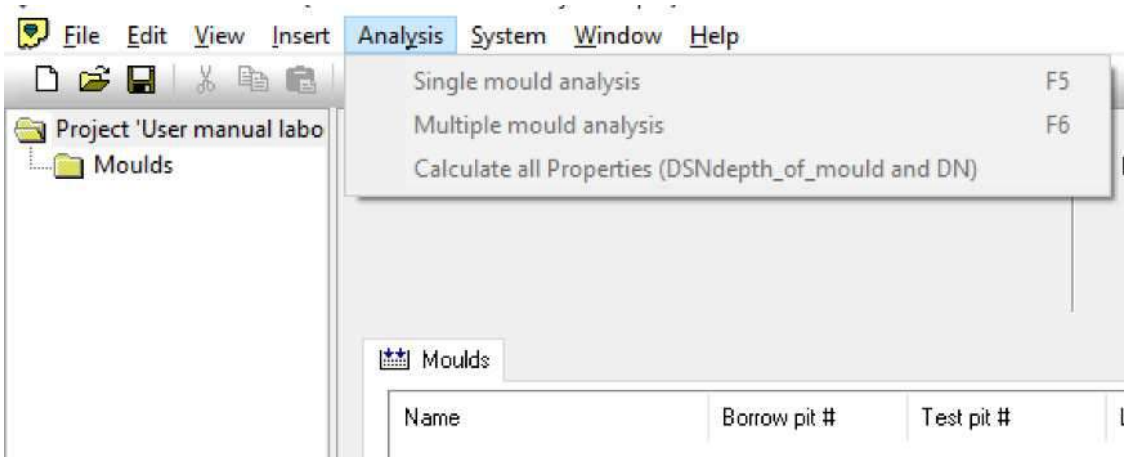


Figure 4-7: Analysis menu

4.2.3 System

Provides Laboratory Report Options. It is recommended to leave these with the default settings.

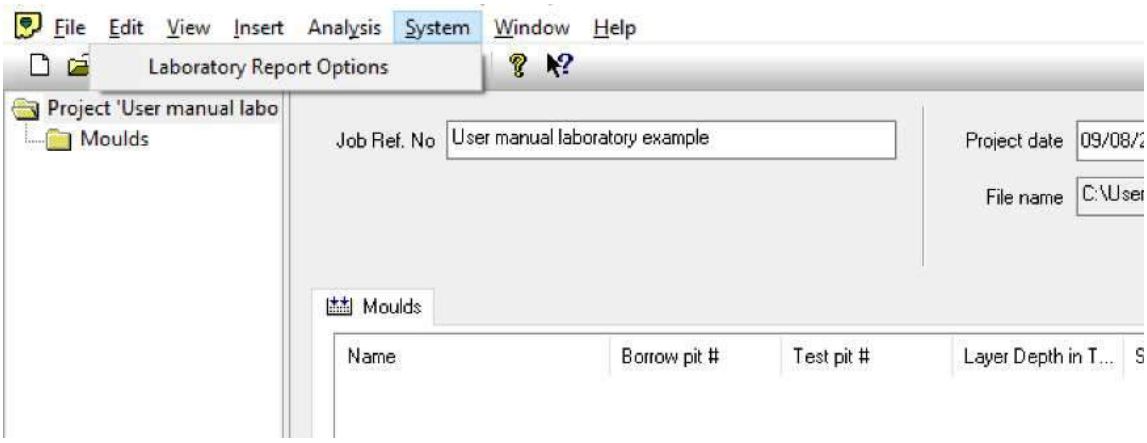


Figure 4-8: System menu

4.3 Entering Laboratory DN test data

- Select "New mould" from the menu or press the short-cut icon.
- Assign a "Sample no" and "Mould no" for clear identification of the test data.
- Identify the location where the sample was collected (Figure 5-9).

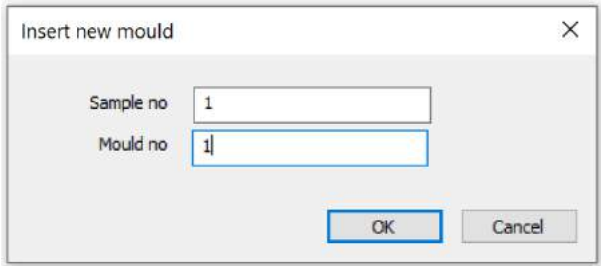


Figure 4-9: Assign Sample and Mould no

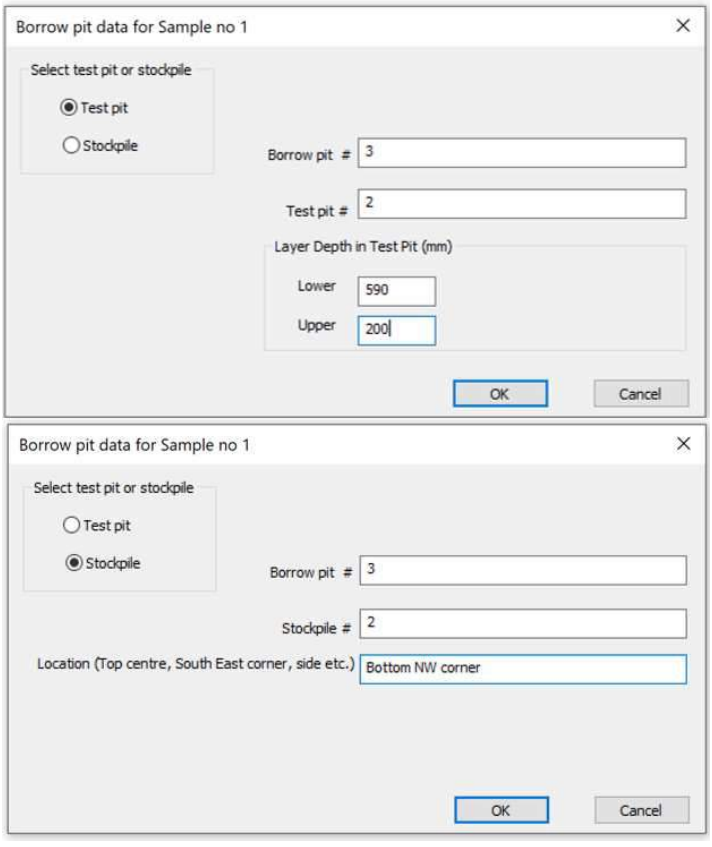


Figure 4-10: Identification of sampling location

- Clicking OK brings up the screen for entering Laboratory test data.

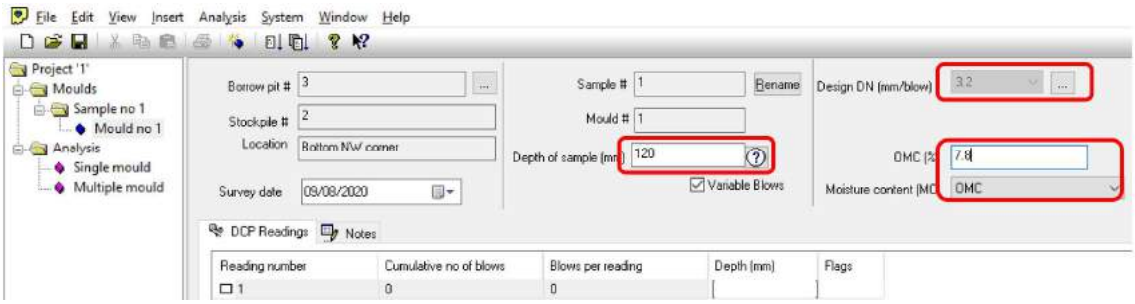


Figure 4-11: Screen for entering laboratory test data

- Enter the sample depth. Clicking (?) brings up Figure 4-13.
- The depth should be measured from the base plate to the top of the sample inside the mould.
- Enter the required DN value for the layer. In this case, 3.2 mm/blow for TLC 0.3 base material.
- Enter the OMC for the material being tested and the moisture content at which the test is being undertaken. In this case, at OMC.

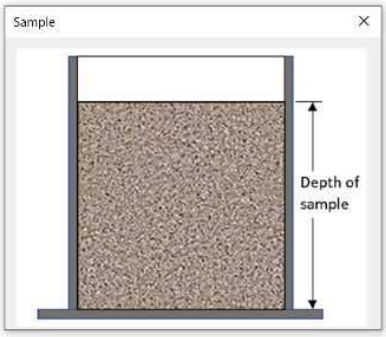


Figure 4-12: Depth of sample

- Select the compactive effort used for compaction of the sample.
  - Heavy (4.5 kg rammer, 5 layers, 55 blow/layer)
  - Intermediate (4.5 kg rammer, 5 layers, 25 blows/layer)
  - Light (2.5 kg rammer, 3 layers, 55 blows/layer)
- Enter the DCP readings as the test is being undertaken or record the readings on a DCP test sheet.

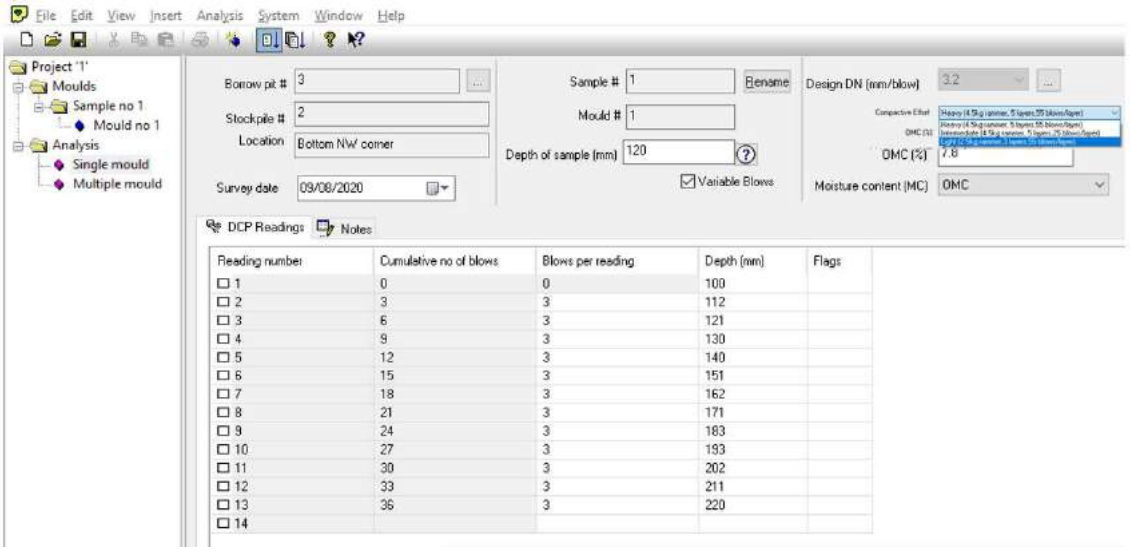


Figure 4-13: Laboratory DN test DCP readings

4.4 Laboratory DN test analysis

As for the DCP field data, the laboratory test data can be analysed for single tests or for a group of tests undertaken at the same moisture content and compactive effort.

4.4.1 Single mould analysis

- Select "Single mould analysis" in the Analysis menu or click the short-cut icon.
- Select the test to be analysed. Clicking OK brings up the test result (Figure 4-15).

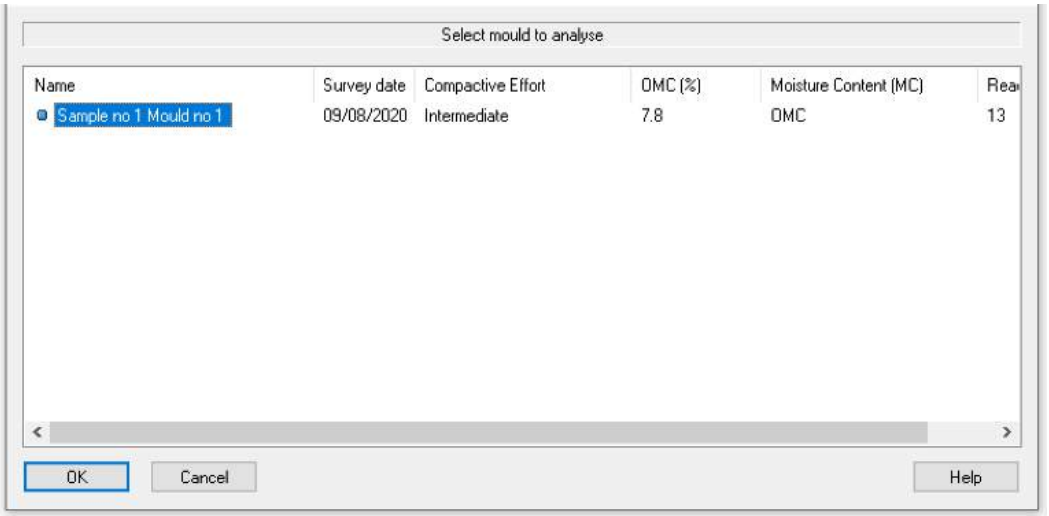


Figure 4-14: Selectin of single mould for analysis

- The best-fit curve in the middle of the mould (disregarding the top and bottom 15 mm of the sample) is taken to be a representative value. In this case, the DN value is marginally higher than the 3.2 mm/blow requirement.

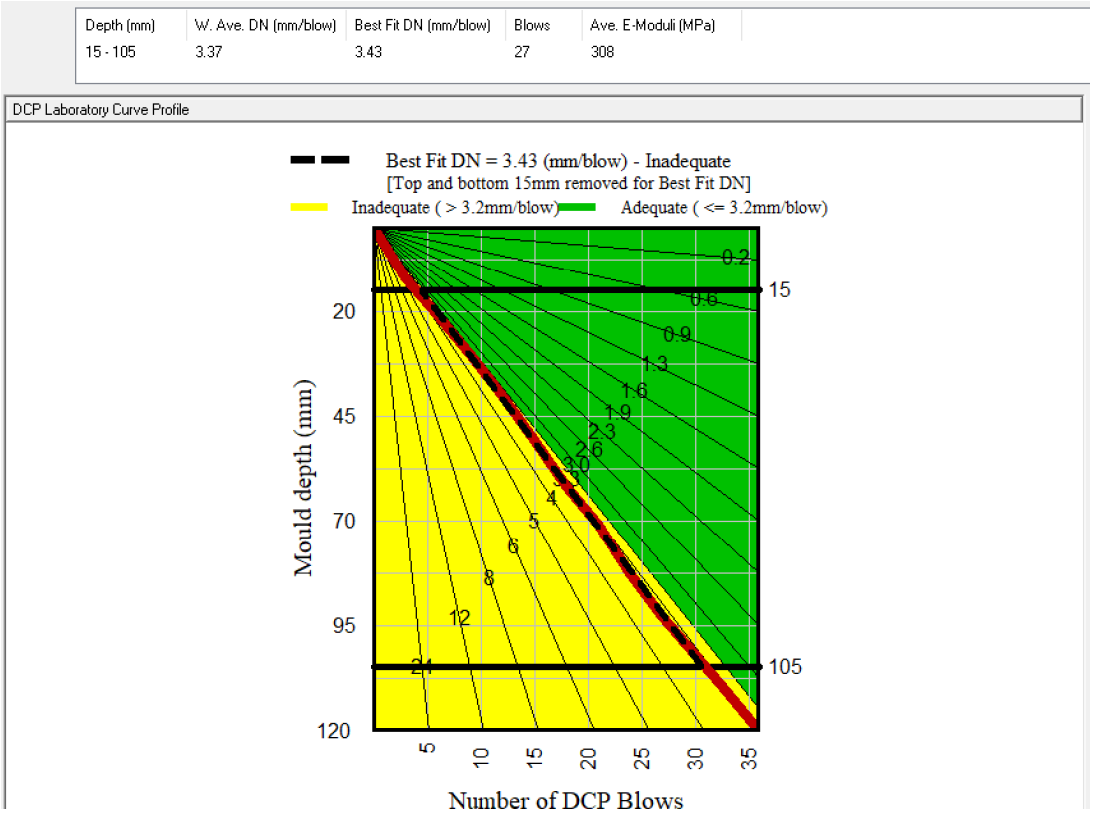


Figure 4-15: Single mould analysis result

4.4.2 Multiple mould analysis

A minimum of three tests at the same moisture content and compactive effort should be undertaken and analysed to establish a representative DN value for design.

- Select "Multiple mould analysis" in the Analysis menu or click the short-cut icon.

- Select tests to be analysed together and click OK.

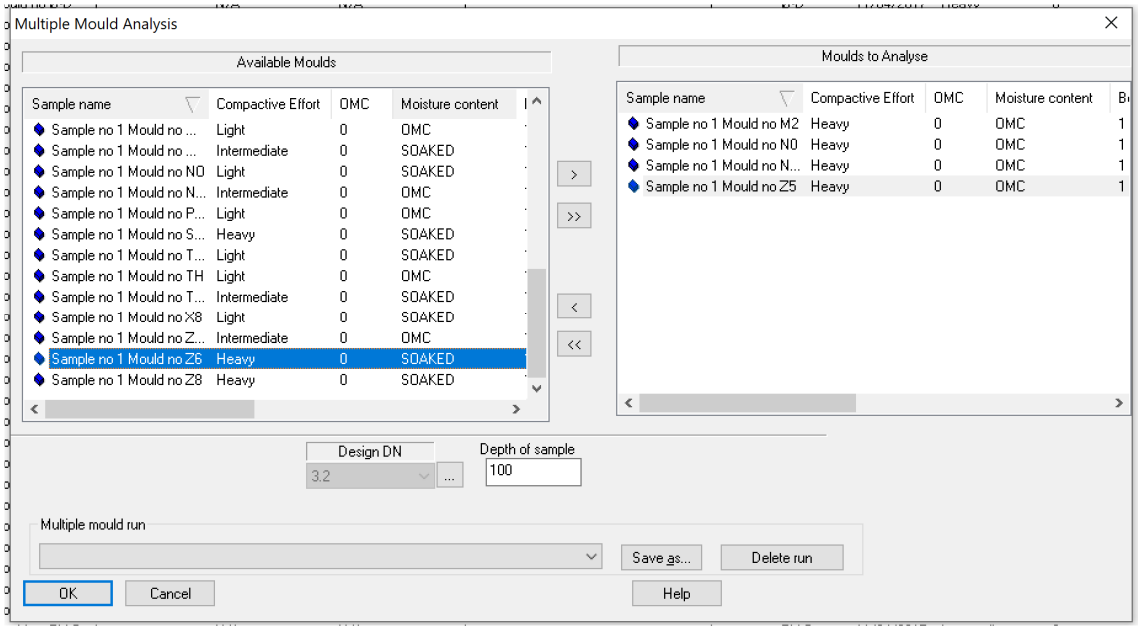


Figure 4-16: Selection of moulds for multiple mould analysis

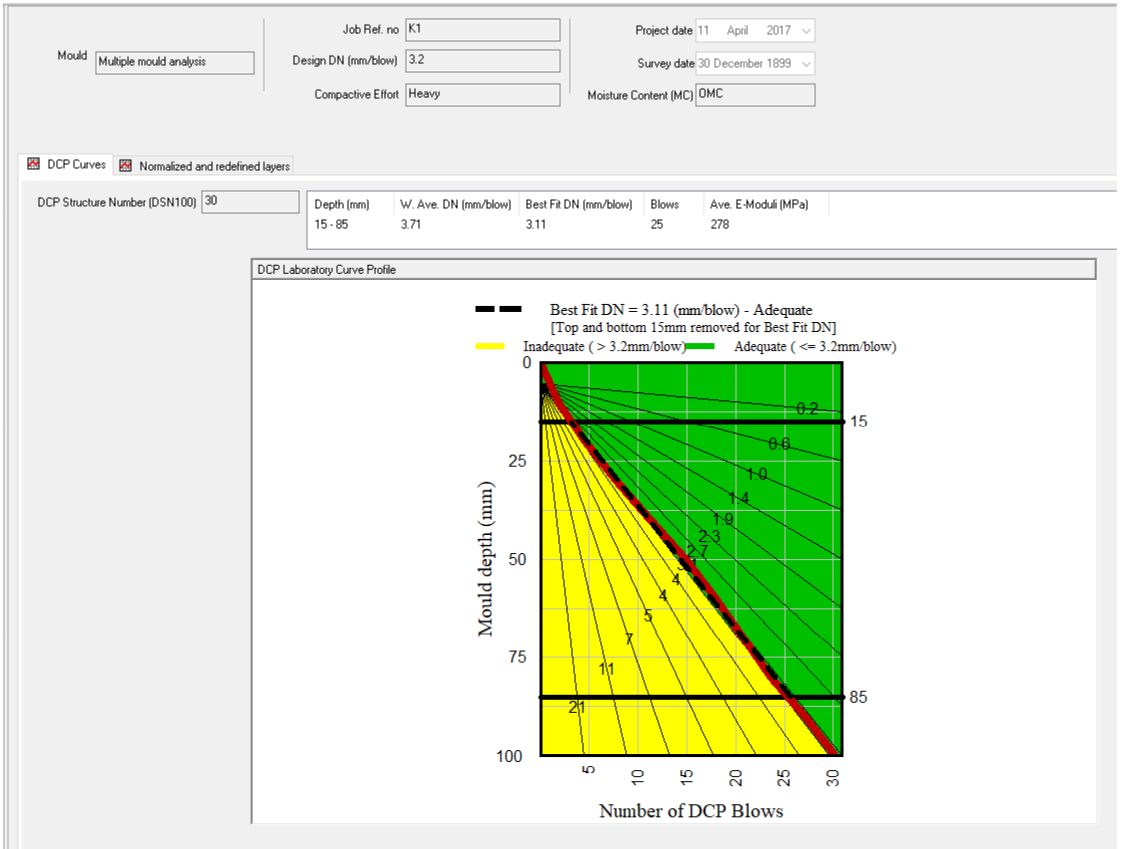


Figure 4-17: Multiple mould analysis result

- In this case, the “best fit” DN value is marginally better than the specification.

4.5 Report options

As for field projects, report options for the laboratory projects are available in the File menu.

- Detailed report, 3 pages (Figure 4-18 to Figure 4-20).
- Summary Report, 1 page (Figure 4-21).

DCP Detailed Report - Multiple Mould Analysis

Job Ref. no K1
Project date: 11 April, 2017 **Analysis date:** 03 October, 2020

Moulds included in analysis

Borrow Pit #	Stockpile #	Stockpile Location	Sample #	Mould #	Survey Date	OMC (%)	Moisture Content	Compactive Effort
1	1		1	Z5	11 April 2017	0	OMC	Heavy
1	1		1	N0	11 April 2017	0	OMC	Heavy
1	1		1	M2	11 April 2017	0	OMC	Heavy
1	1		1	6M	11 April 2017	0	OMC	Heavy
1	1		1	N1-D	11 April 2017	0	OMC	Heavy
1	1		1	C1-D	11 April 2017	0	OMC	Heavy

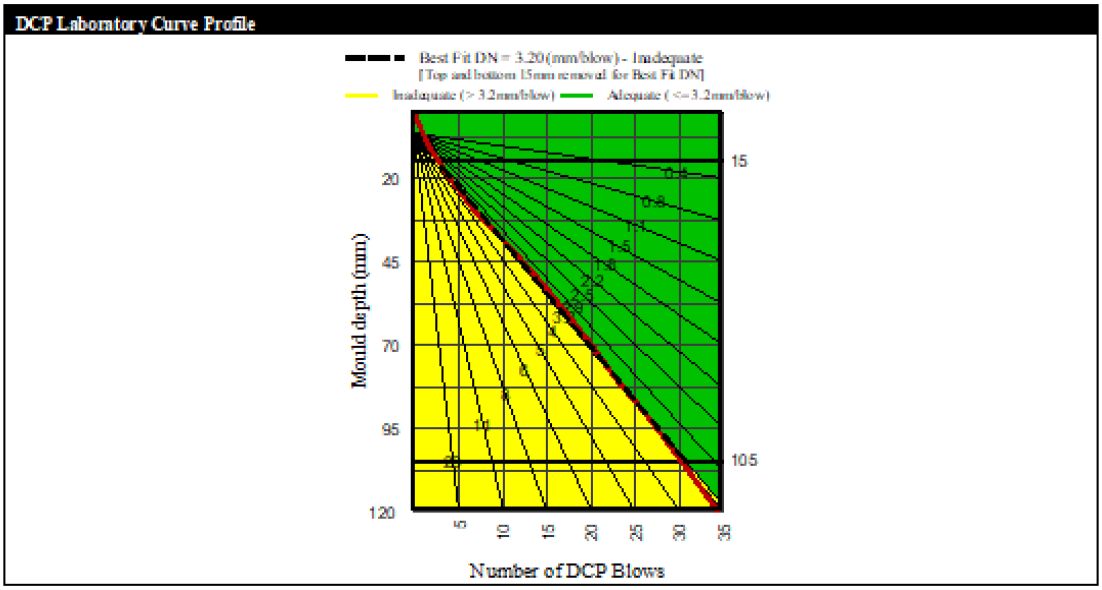
Compactive Effort Heavy
Design DN (mm/blow): 3.2 **Moisture Content:** OMC
Multiple Mould Run: Previous selection

Average equivalent strength (Existing Moulds)

Depth (mm)	W. Ave. DN (mm / blow)	Best Fit DN (mm / blow)	Blows	Ave. E-Moduli (MPa)
15 - 105	3.99	3.20	30	257

** Weighted average penetration rate*

DCP Laboratory Curve Profile



Average equivalent strength (Redefined-EasyDCP Moulds)

Depth (mm)	W. Ave. DN. (mm / blow)	Blows	Ave. E-Moduli (MPa)
0 - 120	4.09	35	250

** Weighted average penetration rate*

Figure 4-18: Detailed Report - Multiple mould analysis, page 1

Summary of + and - Areas (Curve fitting table - Existing moulds)

Depth (mm)	Cumulative Area (% mm), A
0 - 54	-1147
55 - 76	83
77 - 78	-5
79 - 82	4
83 - 84	-4
85 - 101	63
102 - 102	-2
103 - 106	6
107 - 108	-5
109 - 109	1
110 - 119	-55
Absolute Area	1375

Figure 4-19: Detailed Report - Multiple mould analysis, page 2

DCP Penetration data

From-To (mm)	Depth (mm)	Blows per 10mm	W. Ave. DN. (mm/blow)	Ave. E-Moduli (MPa)
1 - 10	10	2	6.00	167
11 - 20	20	4	4.09	250
21 - 30	30	7	3.41	304
31 - 40	40	11	2.75	381
41 - 50	50	14	2.92	357
51 - 60	60	17	3.18	327
61 - 70	70	20	3.44	301
71 - 80	80	23	3.60	286
81 - 90	90	26	3.13	332
91 - 100	100	29	3.45	300
101 - 110	110	32	3.60	286
111 - 120	120	35	3.60	286

** Weighted average penetration rate*

Figure 4-20: Detailed Report - Multiple mould analysis, page 3

DCP Summary Report - Multiple Mould Analysis

Job Ref. no	K1		
Project date:	11 April, 2017	**Analysis date:**	04 October, 2020
Compactive Effort	Heavy		
Design DN (mm/blow):	3.2	**Moisture Content:**	OMC
Multiple Mould Run:	Previous selection		

Average equivalent strength (Existing Moulds)

Depth (mm)	W. Ave. DN (mm / blow)	Best Fit DN (mm / blow)	Blows	Ave. E-Moduli (MPa)
15 - 105	3.99	3.20	30	257

Average equivalent strength (Redefined-EasyDCP Moulds)

Depth (mm)	W. Ave. DN. (mm / blow)	Blows	Ave. E-Moduli (MPa)
0 - 120	4.09	35	250

DCP Laboratory Curve Profile

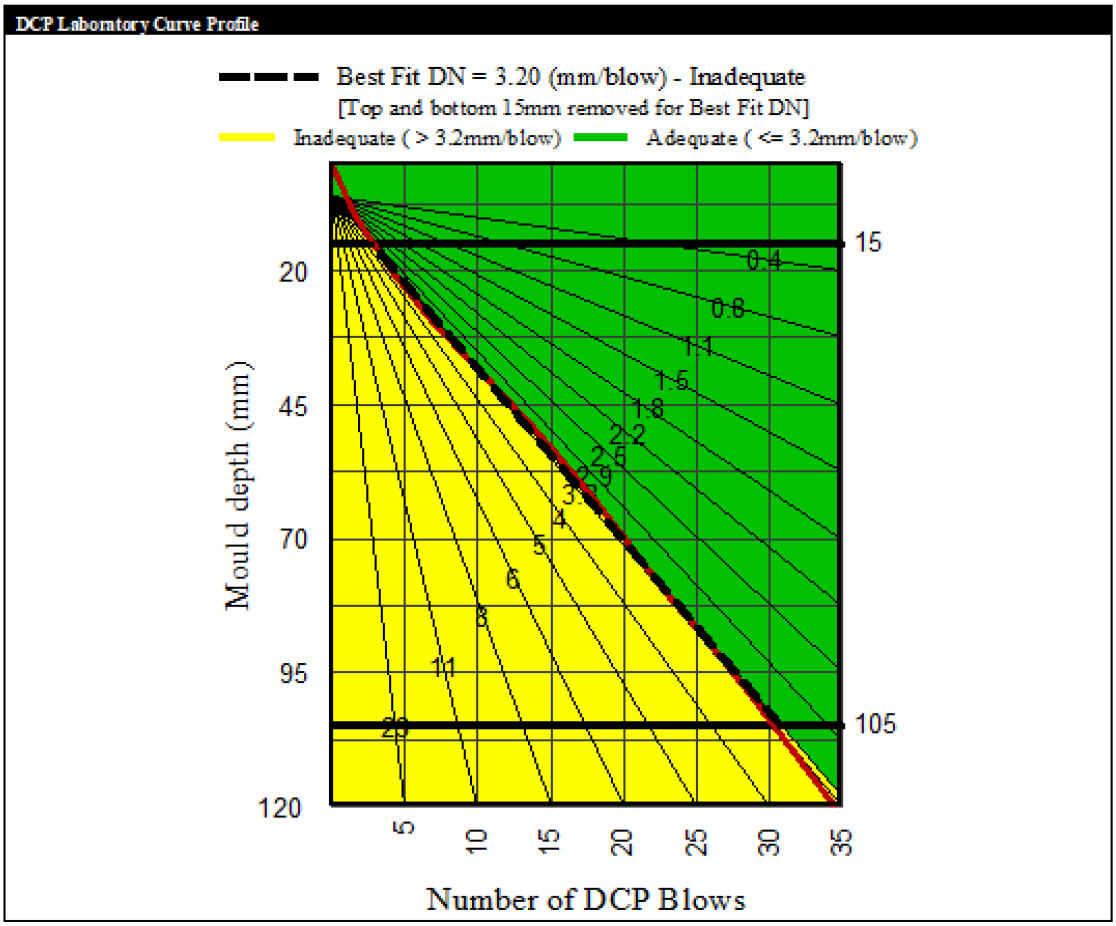


Figure 4-21: Summary Report - Multiple mould analysis

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