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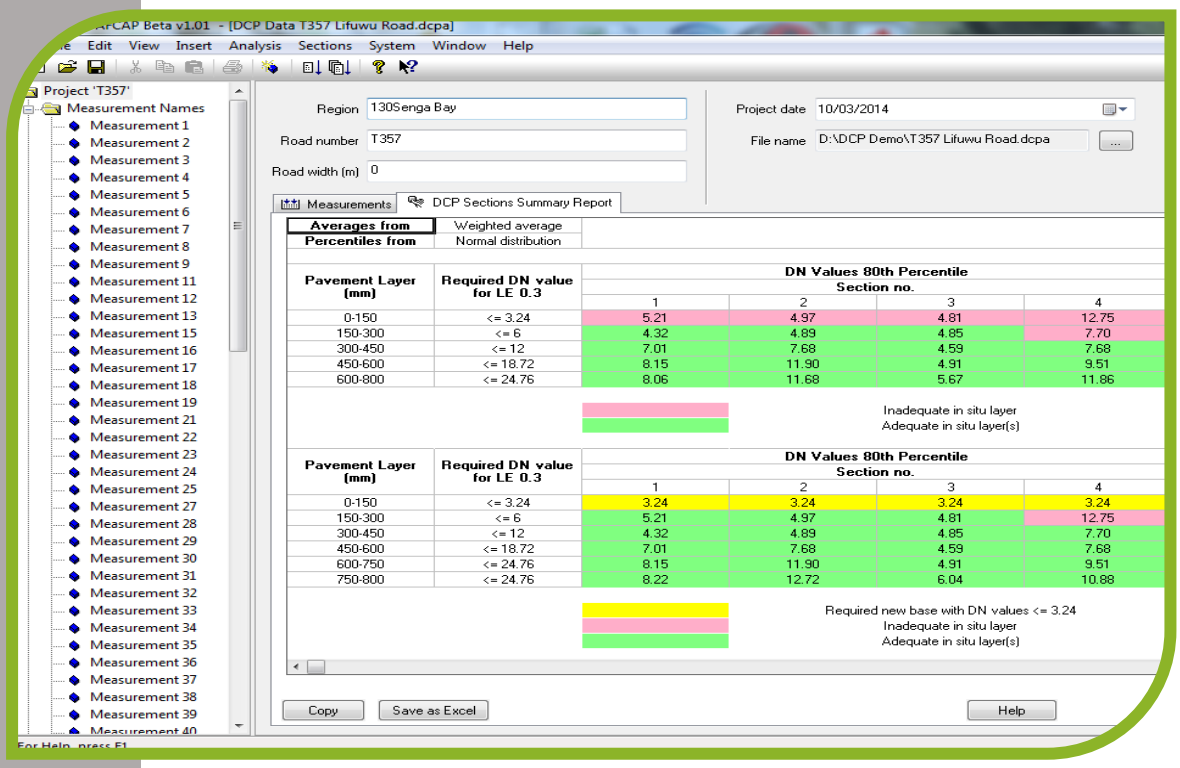
Peer Review of the Improvements to the WinDCP software for Pavement Design of Low Volume Roads

Final Summary Report



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Cover Photo: WinDCP AfCAP Screenshot

Quality assurance and review table			
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Key words

DCP, DCP-DN Design method, WinDCP, WinDCP AfCAP

Acronyms and Abbreviations

ADB	Asian Development Bank
AfCAP	Africa Community Access Partnership
AsCAP	Asia Community Access Partnership
CSIR	Council for Scientific and Industrial Research
DCP	Dynamic Cone Penetrometer
DN	DCP penetration in mm/blow
GPS	Global positioning system
LVR	Low Volume Road
PRT	Peer Review Team
SHF	Software Help File
RECAP	Research for Community Access Partnership
RTM	Regional Technical Manager
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, UK)

Contents

Executive summary

The advent of the DCP-DN method of pavement design has triggered a need to upgrade the CSIR WinDCP Ver 5.1 software to take account of relatively recent developments in low volume road technology. To this end, the South African Council for Scientific and Industrial Research (CSIR), under commission from AfCAP, has been tasked with the upgrading of the software and with the revision of the User Manual + Help File.

AfCAP has also appointed a Peer Review Team (PRT), comprising practitioners with varied experience in the use of the WinDCP software, to review and comment on the improvements to it that are being made CSIR. It was originally envisaged that the review is being undertaken in three stages as follows:

- Stage 1: PRT review and comments on June 2015 CSIR Progress Report based on partially completed Beta 1.01 version of the software.
- Stage 2: PRT review and comments on CSIR Draft Final Report based on test-run of the DCP-DN design procedure using the Beta v1.02 of the software (completed).
- Stage 3: PRT review and comments of final version of software which will be based on comments emanating from Stage 2, leading to a final meeting at CSIR.

In the event, it became necessary to also hold an unscheduled 2-day workshop at CSIR to discuss the large number of comments emanating from the PRT review of the Beta 1.01 version of the software.

The main outcomes of the project may be summarised as follows:

1) The CSIR Win DCP 5.1 software has been substantially revamped to take account of the most recent developments in low volume road design based on the DCP-DN method.
2) The AFCAP LVR Win DCP software + SHF is now much more user friendly, and can be used much more intuitively, than previously.
3) The User Manual does not currently reflect the PRT requirements and should be reviewed in the next phase of the project.
4) There are a few software issues that came to light during the trialling of the Alpha ver 1.00 of the AFCAP LVR Win DCP software that need to be addressed in the next phase of the project.

In terms of the way forward, the following recommnedations are made:

1) A second phase of the project should be considered to allow the various shortcomings identified from using the softare and the User Manual to be adequately addressed in a staged manner.
2) The outline scope of work envisaged in the next phase would be:
    a. The PRT to hold a 1-day inception meeting with CSIR to discuss the various inprovements required to the software and User Manual as recorded in a workshop Report.
    b. The CSIR to update the software and User Manual in line with the agreements reached at inception workshop.
    c. The PRT to reveiw the updated software and user Manual and provide feedback to CSIR.
    d. The CSIR to finalise the software and User Manual which would be discussed at a final 1-day workshop at CSIR.

1 Introduction

1.1 Background

The Africa Community Access Programme (AfCAP) is a programme of research and knowledge dissemination funded by the UK government though the Department for International Development (DFID). AfCAP is promoting safe and sustainable rural access in Africa through research and knowledge sharing between participating countries and the wider community.

The WinDCP 5.1 software developed by Council for Scientific and Industrial Research (CSIR), South Africa, has been identified as an appropriate tool for pavement design of low volume roads (LVR). In this regard, a number of training courses have been held in various countries for private sector consultants and government staff on the use of the DCP-DN Design Method and related software. It has, however, become apparent that the software needs to be upgraded to take account of relatively recent developments in low volume roads technology that are not catered for in the current version of the software. In addition, the software needs to be made more user friendly to suit the needs of first-time users.

In light of the above, AfCAP has commissioned CSIR to undertake the upgrading of the WinDCP software, for which various suggestions for improvement were first discussed by a number of practitioners at a meeting held at CSIR in August 2013. Since then, various improvements have been incorporated in the new WinDCP AfCAP software which are based on the DCP-DN method of pavement design. A Peer Review Team (PRT) comprising practitioners and experts were selected to review the improved versions of the software and user manual as per the stages of development outlined below.

1.2 Objective of Assignment

The objective of the assignment is for the PRT to undertake a peer review of the improvements and modifications that were being undertaken by CSIR to the Win DCP 5.1 software and associated manual and Help Files.

1.3 Scope of Work

The scope of work envisaged in the Terms of Reference (ToR) for undertaking the peer review of improvements to the Win DCP 5.1 software was as follows:

Stage 1

1) Review of June 2015 CSIR Progress Report.
2) Test-Run the DCP-DN design procedure using the Beta v1.01 of the software.
3) Report on the above activities.

Stage 2

1) Review of Beta version 1.02:
2) Review of the Users' Manual and Help File
3) Report on the above activities

Stage 3

1) Final presentation of software and User Manual by CSIR including participation of the PRT in this final activity.

1.4 Project Deliverables

The project deliverables stipulated in the ToR are in line with the stages outlined in Section 1.3 above and may be summarised as follows:

1) Stage 1: Report on the WinDCP status with recommendations, as detailed above
2) Stage 2: Report on the WinDCP status with recommendations, as detailed above.
3) Stage3: Short (1-3 page) summary of the Stage 3 event.
4) Final Summary Report (up to 5 pages) incorporating all above 3 reports.

1.5 Programme

The assignment was expected to be carried out within a period of 5 (five) months commencing in July 2015. The following key milestones are expected to be achieved:

- *By 18th September 2015*. Submission of consolidated comments on the June 2015 Progress Report comprising the partially completed beta version (Phase 1).
- *By 30th October 2015*. Submission of consolidated comments on the completed beta version including Help file and associated WinDCP AFCAP Manual.
- *By 30th November 2015*. The one-day meeting for oral presentation of the peer reviewed final version.

1.6 Purpose and Scope of the Report

The purpose of this Final Report is to summarise the outputs of the three stages of the project as indicated above. The report also includes feedback from the AFCAP trainers involved in running a training course in Ghana on the DCP design of low volume roads based on the DCP method at which the new software was trialled. Finally, the report makes recommendations on the way forward for dealing with aspects of the software upgrade that still need to be addressed.

2 Summary of Project Outcomes

2.1 Stage 1a

(a) CSIR activities

- June 2015 Progress Report
- Beta v 1.10 of upgraded software

(b) PRT activities

- Review of CSIR June 2015 Progress Report
- Test run of DCP-DN design procedure using Beta v1.01 of the software
- Preparation of Stage 1 Progress Report dated 15th October, 2015.

(c) Main outcomes

- Significant number of comments from PRT of a conceptual nature related to DCP-DN design method as well as those of a programming nature related to perceived shortcomings of the software
- Recommendation to hold an unscheduled 2-day workshop to discuss comments and agree manner of addressing them in next upgrade of software.

2.2 Stage 1b

CSIR activities

- Preparation of Beta v 1.02 based on PRT comments included in Stage 1 Progress Report.
- Demonstration of upgraded software showing how PRT comments had been accommodated in upgraded software.

PRT Activities

- Review of Beta ver 1.02
- Participation in 2-day workshop at CSIR on 30 November and 1st December, 2016.
- Preparation of Stage 1 Workshop Report dated 7th December, 2015.

Main outcomes

- CSIR to produce updated version of software and Software Help File by 8th January, 2016 for review by PRT.

2.3 Stage 2

CSIR activities

- Preparation of Beta ver 1.03 of software based on PRT comments contained in Stage 1 Workshop Report dated 7th December, 2015.

PRT activities

- Review of software and User Manual discussed at workshop held on 7th December, 2015 as updated software and manual inadvertently not received by PRT by 8th January, 2015.
- Preparation of Stage 2 Progress Report dated 8th January, 2016.

Outcomes

- PRT comments on structure and content of User Manual and other shortcomings including inclusion of design issues which should be reserved for a design manual.
- Recommendation that final meeting should discuss Stage 2 comments as basis for finalising software and user Manual.

2.4 Stage 3

CSIR activities

- Preparation of Beta ver 1.04 based on PRT comments contained in their Stage 2 Progress Report dated 8th January, 2016.
- Demonstration of upgraded software showing how PRT comments had been accommodated in upgraded software.
- Preparation of Alpha ver 1.00 of AfCAp LVR DCP software + SHF plus User Manual

PRT activities

- Participation in 1-day workshop at CSIR on 15 January, 2016.
- Preparation of Stage 3 Workshop Report dated 20th January, 2016.
- Final Review of software and User Manual discussed at workshop held on 15th January, 2016.
- Preparation of Stage 3 report in e-mail dated 9th February, 2016.

Outcomes

- PRT comments on Alpha ver 1.00 of AfCAP LVR DCP software and User Manual indicating that software updates seem to have been addressed but that User Manual does not reflect PRT requirements.
- PRT recommendation that (1) Alpha ver 1.00 should be trialled at DCP LVR training in Ghana in February, 2016 and that feedback would be provided for next phase of project and (2) User Manual requirements should be addressed in the next phase of the project.

2.5 Feedback from DCP Training in Ghana

The feedback from the AFCAP trainers involved in the DCP training in Ghana is presented in Annex A. In summary, there are a number of software issues that need to be addressed in the next phase of the project that probably would not reasonably have been foreseen until the software was used in practice. In addition, the laboratory module for measuring the DN value needs to be reviewed to bring it in line with actual practice.

3 Summary of Outcomes and Way Forward

3.1 Summary of Outcomes

5) The CSIR Win DCP 5.1 software has been substantially revamped to take account of the most recent developments in low volume road design based on the DCP-DN method.
6) The AfCAP LVR DCP software + SHF is now much more user friendly, and can be used much more intuitively, than previously.
7) The User Manual does not currently reflect the PRT requirements and should be reviewed in the next phase of the project.
8) There are a few software issues that came to light during the trialling of the Alpha ver 1.00 of the AFCAP LVR DCP software that need to be addressed in the next phase of the project.

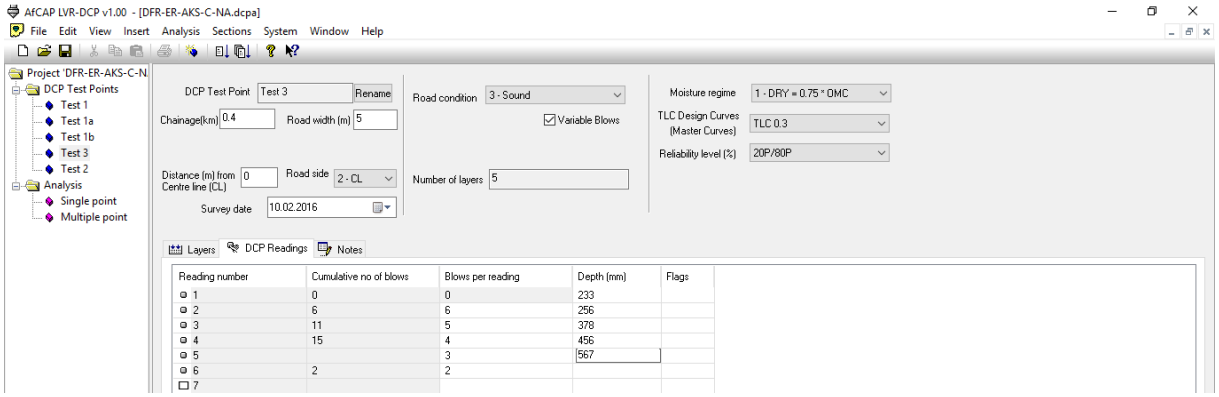
3.2 Way Forward

The following recommendations are made following the completion of the project.

3) A second phase of the project should be considered to allow the various shortcomings of the softare and User Manual to be adequately addressed in a staged manner.
4) The outline scope of work envisaged in the next phase would be:
   a. The PRT to hold a 1-day inception meeting with CSIR to discuss the various inprovements required to the software and User Manual as recorded in a workshop Report.
   b. The CSIR to update the software and User Manual in line with the agreements reached at inception workshop.
   c. The PRT to review the updated software and User Manual and provide feedback to CSIR.
   d. The CSIR to finalise the software and User Manual which would be discussed at a final 1-day workshop at CSIR.

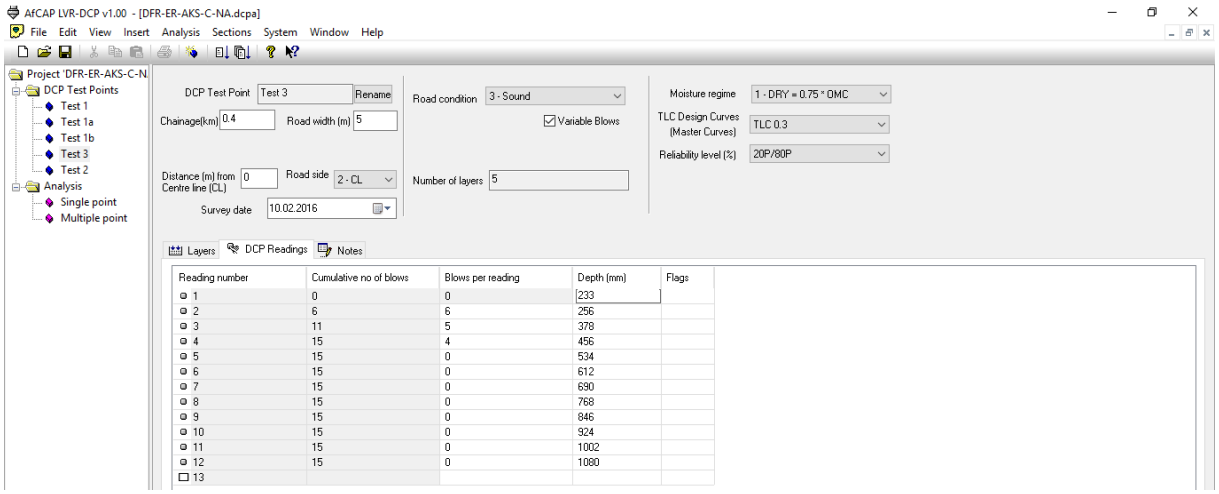
Annex A–Summary of findings of AfCAP LVR-DCP v1.0 and proposals for improvements in Phase 2.

1. DCP data entry screen for Variable Blows option

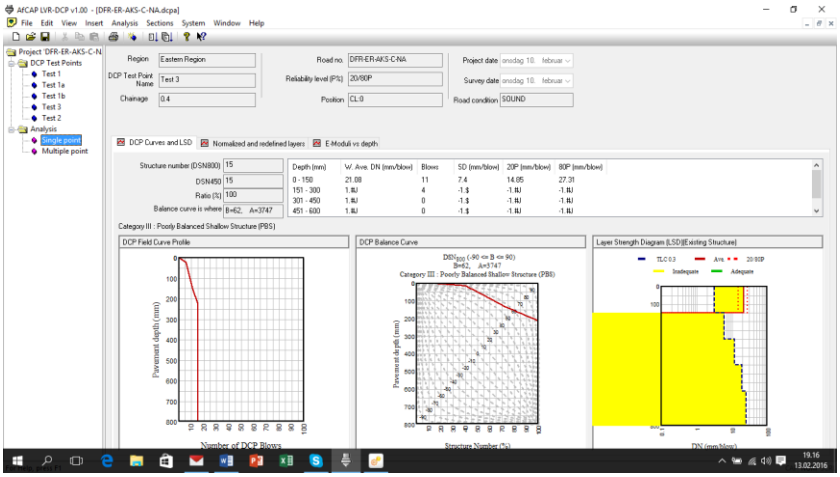


a. Using TAB instead of Enter after entering Depth 456 moved the cursor on step down to the next Depth cell instead of down and to the left to the next Blows per Reading.
b. Then, using left arrow to enter 3 Blows per reading, then Enter to type 567, then Enter again to type 2 Blows per reading, the Cumulative Blows are not added up (the cell is left empty as shown on the screenshot.
c. Likewise, when using Tab after entering Blows per reading, the curser moves down to the next Blows per reading causing the same problem.
d. To correct the error and get correct Cumulative no of Blows, all entries after Reading number 4 must be deleted, then start data entry again from Reading 5.
e. To guard against this potential problem, the Tab and Enter key should be programmed (which I assume can be done) to function in exactly the same manner during data entry.

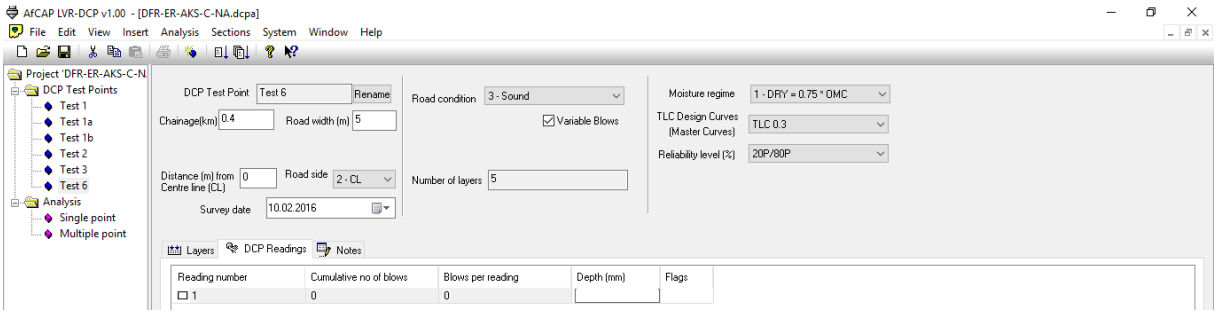
2. Automatic extrapolation function for Variable Blows option



Automatic extrapolation to reach 800 mm depth does not work properly as shown. Blows per reading are entered as zero with the resulting analysis screen as shown below.
User must manually enter Blow per reading, in this case 4, from reading 5 down.

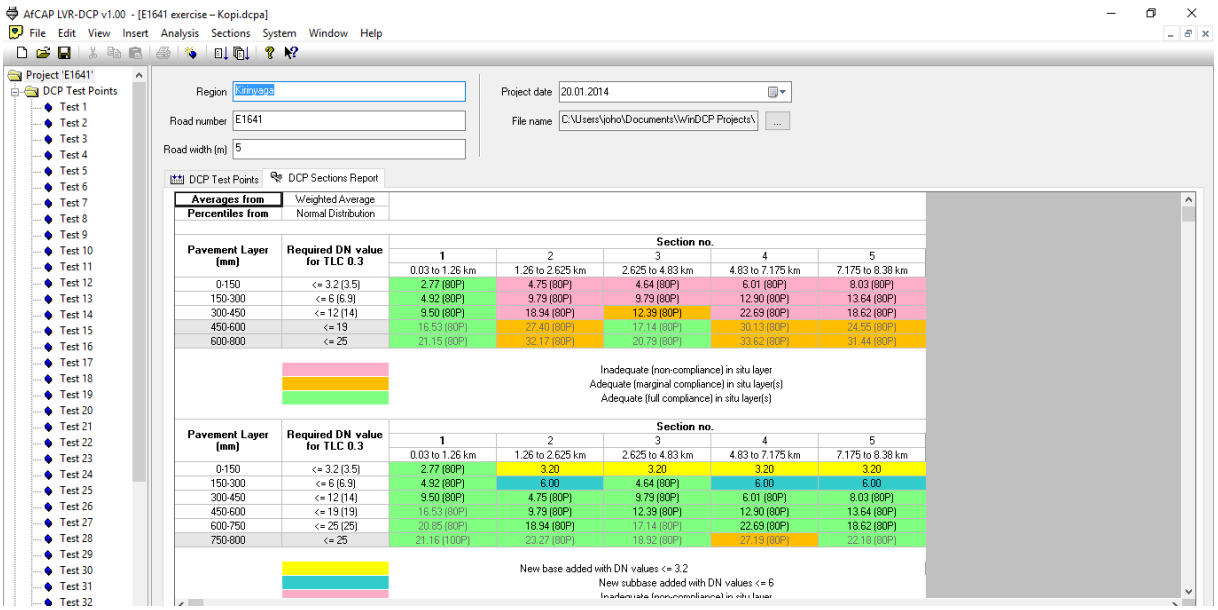


3. Numbering of Test points



In the above example I had entered five test points 1, 1a, 1b, 2 and 3. Then the next Test point is automatically given the number 6. Can this be changed to the next higher number, in this case 4, instead of assigning it the number actual number of the test point to avoid having to rename all following test points to be entered?

4. DCP Section Report



a. The first table with “as is” values is ok except for faint type faces in the two bottom rows. All Section numbers could also be either bold or normal.
b. All legend text for both tables should be left aligned in column under Section 1. Suggest additional text as shown below for the amber legend text.

c. In the second "design" table, the last layer has been split in two, i.e. 650-750 and 750-800, unknown for what reason. Probably just a remnant in the programming from trials with different layer thicknesses

d. Programming errors resulting in unnecessary New Subbase for section 2 and 4. Correct design (in excel) shown below:

Averages from	Weighted Average
Percentiles from	Normal Distribution

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no.				
		1	2	3	4	5
		0.03 to 1.26 km	1.26 to 2.625 km	2.625 to 4.83 km	4.83 to 7.175 km	7.175 to 8.38 km
0-150	<= 3.2 (3.5)	2.77 (80P)	4.75 (80P)	4.64 (80P)	6.01 (80P)	8.03 (80P)
150-300	<= 6 (6.9)	4.92 (80P)	9.79 (80P)	9.79 (80P)	12.90 (80P)	13.64 (80P)
300-450	<= 12 (14)	9.50 (80P)	18.94 (80P)	12.39 (80P)	22.69 (80P)	18.62 (80P)
450-600	<= 19	16.53 (80P)	27.40 (80P)	17.14 (80P)	30.13 (80P)	24.55 (80P)
600-800	<= 25	21.15 (80P)	32.17 (80P)	20.79 (80P)	33.62 (80P)	31.44 (80P)

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)

Pavement Layer (mm)	Required DN value for TLC 0.3	Section no.				
		1	2	3	4	5
		0.03 to 1.26 km	1.26 to 2.625 km	2.625 to 4.83 km	4.83 to 7.175 km	7.175 to 8.38 km
0-150	<= 3.2 (3.5)	2.77 (80P)	3.20	3.20	3.20	3.20
150-300	<= 6 (6.9)	4.92 (80P)	4.75 (80P)	4.64 (80P)	6.01 (80P)	6.00
300-450	<= 12 (14)	9.50 (80P)	9.79 (80P)	9.79 (80P)	12.90 (80P)	8.03 (80P)
450-600	<= 19 (19)	16.53 (80P)	18.94 (80P)	12.39 (80P)	22.69 (80P)	13.64 (80P)
600-800	<= 25 (25)	21.15 (80P)	27.40 (80P)	17.14 (80P)	30.13 (80P)	18.62 (80P)

New base added with DN values <= 3.2
New subbase added with DN values <= 6
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)

e. DN values should be rounded off to max one decimal. Suggest also that DN values ≥ 10 are rounded off to zero decimals. The programme should use the displayed one or zero decimal value for assignment of colours to avoid, say, 6.0 being coloured amber when the actual value in the cell is 6.01xxx (see Section 4 above)

f. This raises the question whether the DCP Section Report should only show the "as is" table and leave the user to do the final design in Excel, which has now become easy with the "save as excel" option. Automating this last step may cause the users to accept the programme design as shown for Section 4, without thinking how they can improve is situ layers, e.g. by drainage improvements, and avoid import of material, in this case for new subbase.

g. Another option could be to present only the "as is" table first, then ask the user to identify sections and layers that need improvement, e.g. by import of new layer(s) or improvement using a coding system. On the basis of these user inputs the final design table would be presented. This would force the user to think through the final design decisions in the same way they would do in Excel.

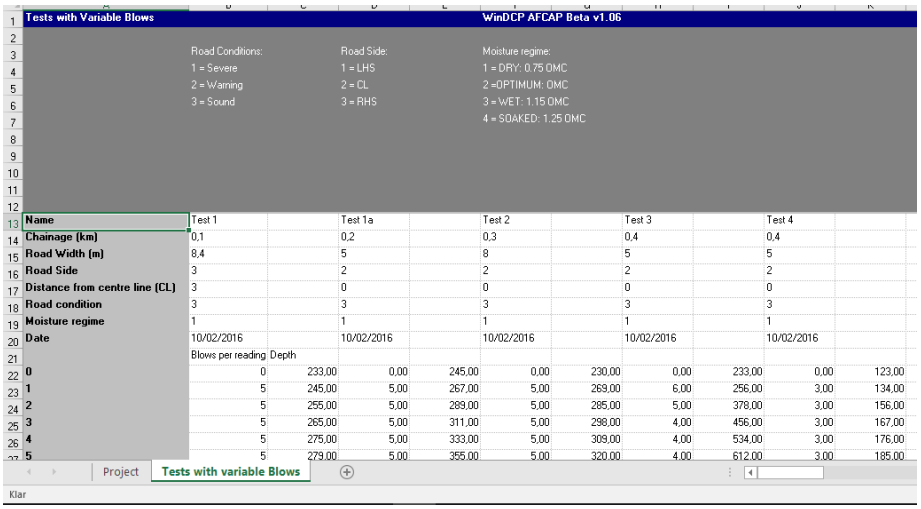
5. Export/import project to/from Excel and Excel Templates

a. Export/Import is seemingly working fine both ways.

b. Decimal places in template for Blows per reading and Depth should be zero (default). See screenshot below.

c. Templates should be formatted as Forms only allowing entries in the specific cells and giving warnings if all required data are not entered before file is saved.

d. Road width should be taken out, both from the Templates and from the opening screen for creating a new project file, as the width can vary significantly along the road and width is to be recorded for each DCP Test Point.



Tests with Variable Blows — WinDCP AFCAP Beta v1.06

Road Conditions: 1 = Severe; 2 = Warning; 3 = Sound

Road Side: 1 = LHS; 2 = CL; 3 = RHS

Moisture regime: 1 = DRY: 0.75 OMC; 2 =OPTIMUM: OMC; 3 = WET: 1.15 OMC; 4 = SOAKED: 1.25 OMC

Name	Test 1	Test 1a	Test 2	Test 3	Test 4
Chainage (km)	0,1	0,2	0,3	0,4	0,4
Road Width (m)	8,4	5	8	5	5
Road Side	3	2	2	2	2
Distance from centre line (CL)	3	0	0	0	0
Road condition	3	3	3	3	3
Moisture regime	1	1	1	1	1
Date	10/02/2016	10/02/2016	10/02/2016	10/02/2016	10/02/2016
	Blows per reading	Depth			
0	0	233,00	0,00	245,00	0,00	230,00	0,00	233,00	0,00	123,00
1	5	245,00	5,00	267,00	5,00	269,00	6,00	256,00	3,00	134,00
2	5	255,00	5,00	289,00	5,00	285,00	5,00	378,00	3,00	156,00
3	5	265,00	5,00	311,00	5,00	298,00	4,00	456,00	3,00	167,00
4	5	275,00	5,00	333,00	5,00	309,00	4,00	534,00	3,00	176,00
5	5	279,00	5,00	355,00	5,00	320,00	4,00	612,00	3,00	185,00

Project | Tests with variable Blows

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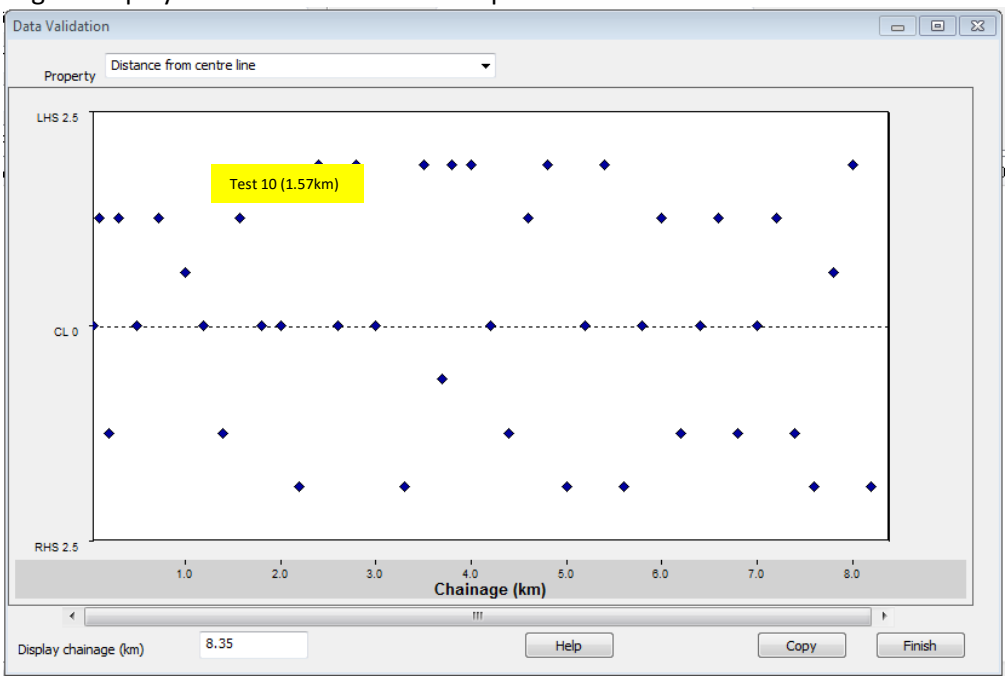
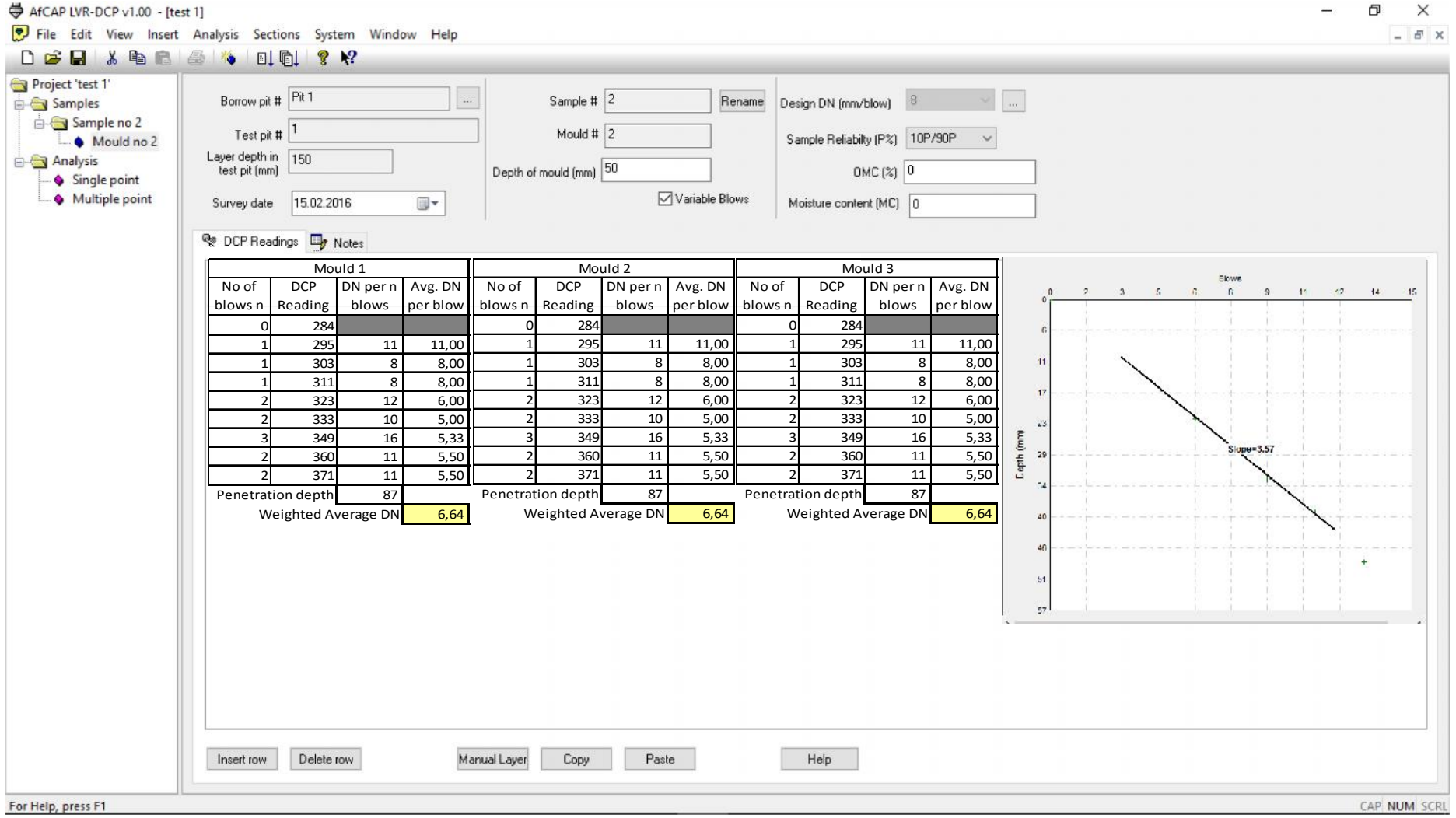
6. Data validation

It was suggested by some of the trainees to display the Test no and Chainage on the screen as shown.

Possible, but not recommended as it would make the screen too cluttered. Test No and Chainage is displayed when cursor hovers on point.



7. Proposed layout for Lab DN data entry screen



Notes to Lab DN data entry screen proposal:

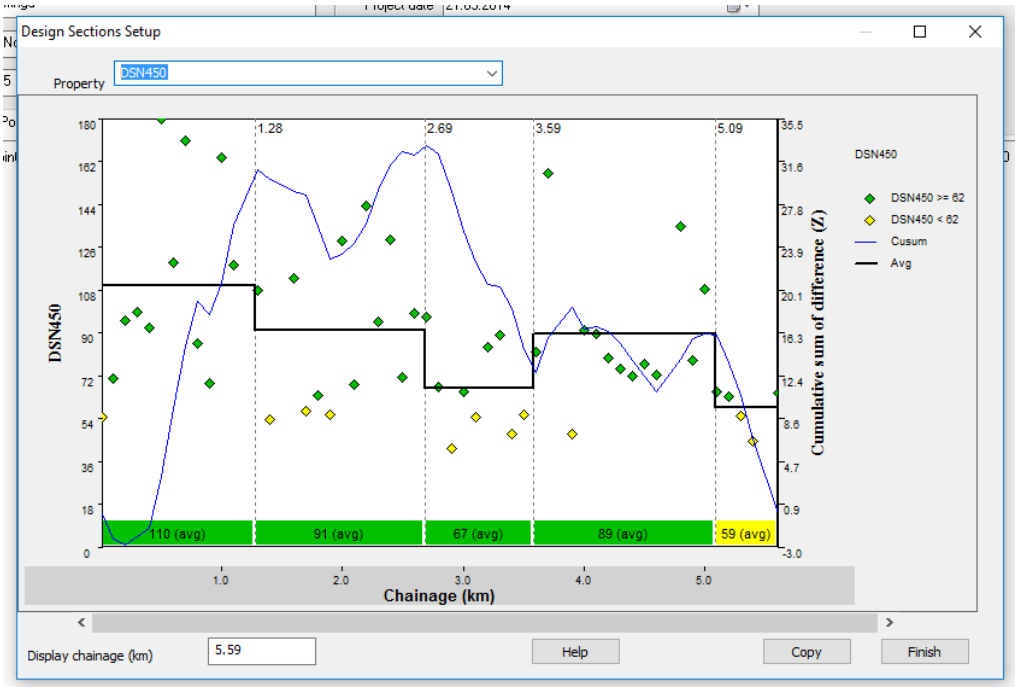
- Provision made for three tests from same sample. More lines to be added to fill the available space
- Curves automatically plotted in diagram to the right as tests are carried out. User to add "best fit" line for the three samples from the middle of the moulds to determine representative Lab DN for the sample. Clicking on the diagram should enlarge it for fitting of line, enable copying etc. similar to the LSD etc. in the field module
- Top panel:
    - Delete field for "Mould #", since this is recorded for each mould as shown below
    - "Depth of mould" should rather be "Depth of sample in mould". The user can then monitor the penetration depth as test progresses to ensure that the tip of the cone does not hit the base plate. Effective max penetration depth will be: Depth of sample in mould – 23 mm (height of cone plus 3 mm shoulder)
    - Fields for "Compaction effort" (e.g. BS Heavy) and "Confinement factor" to be added.
    - Effective Field DN automatically calculated as Lab DN x Confinement Factor
    - "Sample reliability" to be taken out, not relevant for Lab DN test

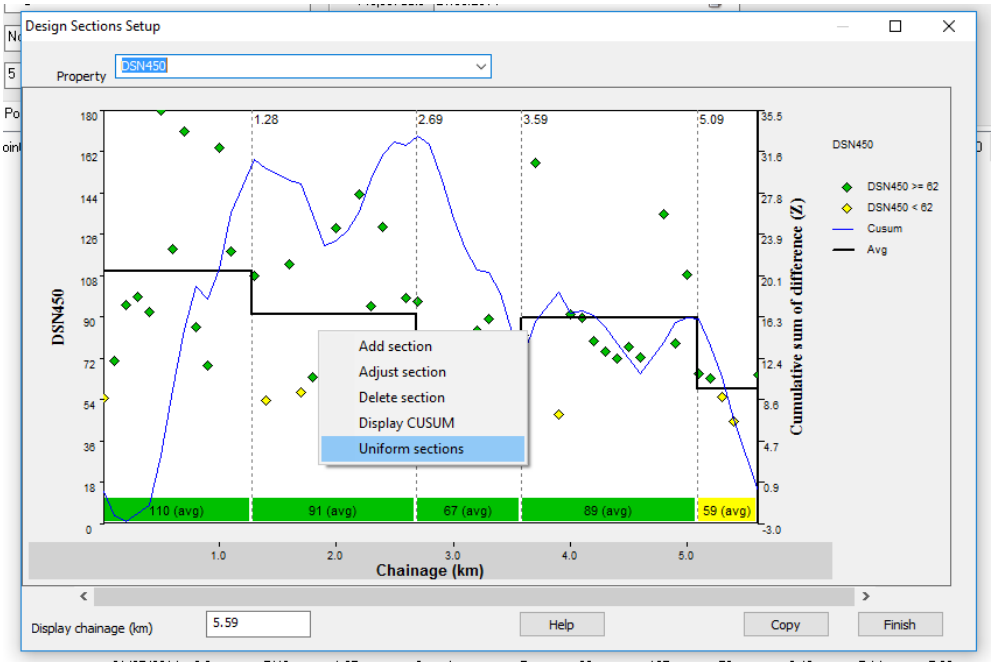
The current version of the Lab module suffers from the same shortcomings as described above for data entry and automatic extrapolation in the field module when using the "variable blows" option. For the Lab module the user must be able to stop the test before the tip hits the base plate without being forced to extrapolate the data set.

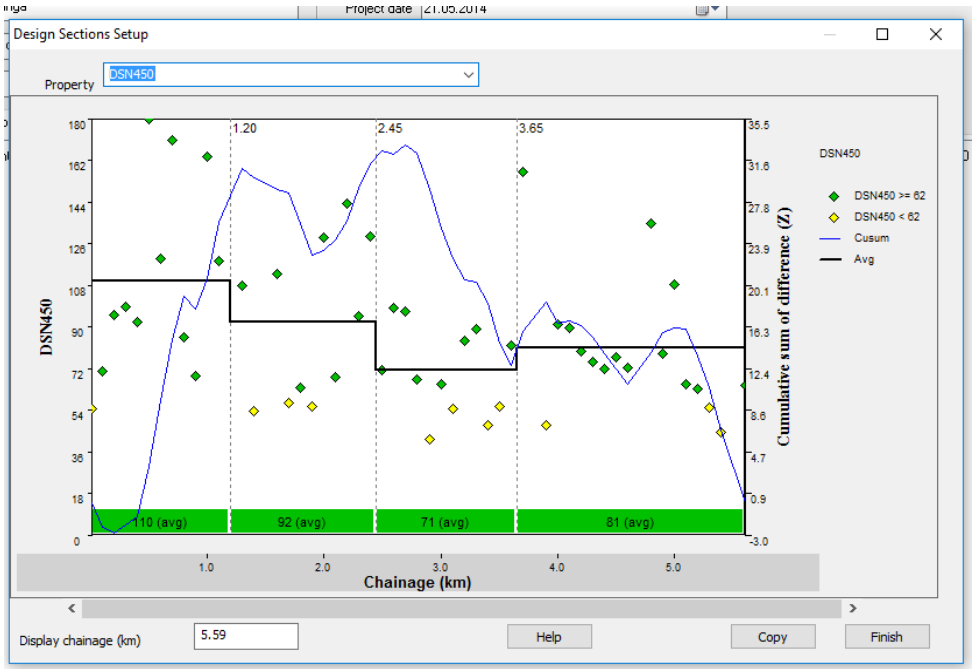
8. Determination of Sections from Properties

The following screen shots illustrates what happens when the user first determines sections, then right-clicks and selects Uniform Sections from the pop-up menu.
The section delimiters are moved and one deleted altogether.
Questions are:

- Which algorithm is used for this automatic selection of Sections?
- Do we need it?





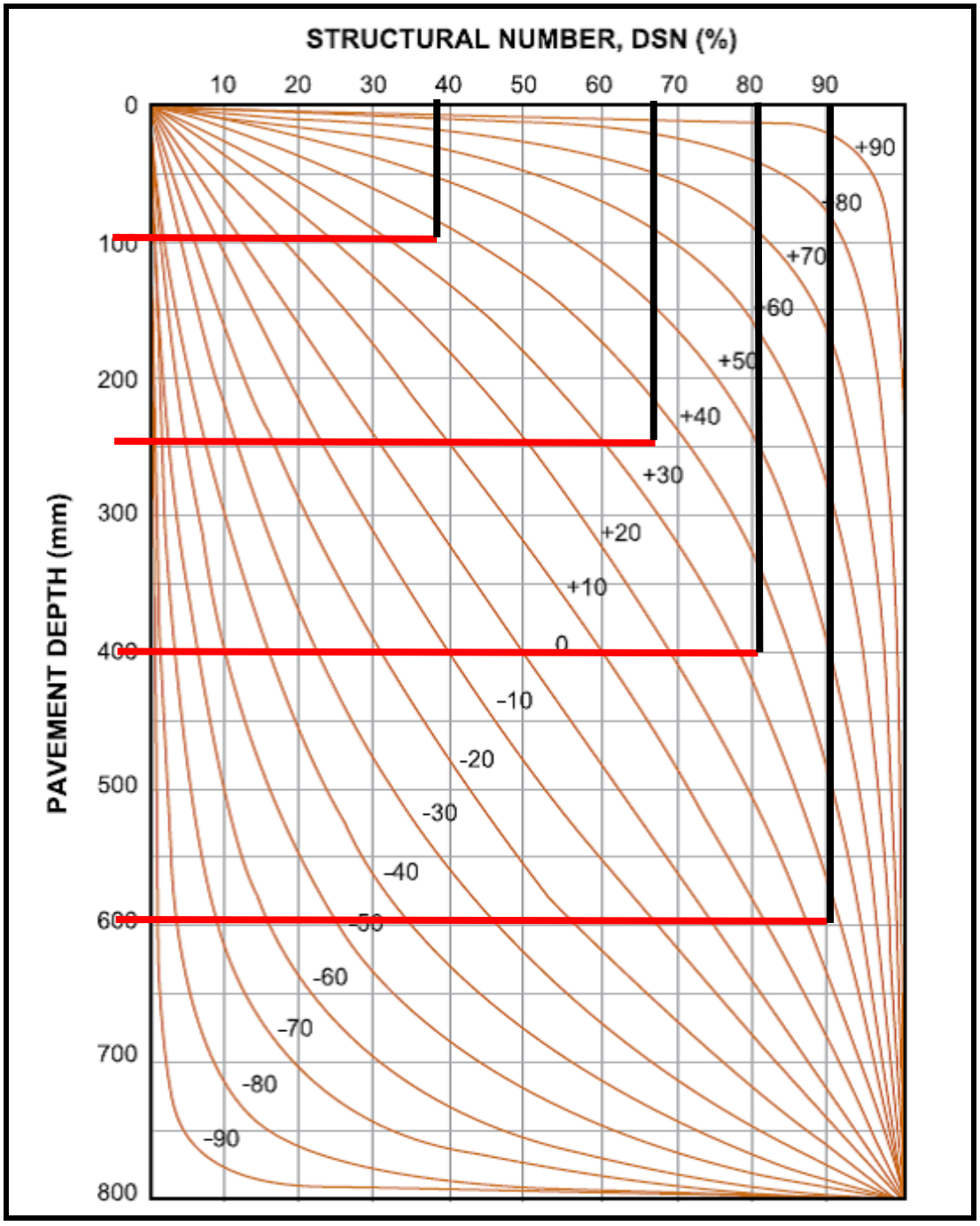


9. How to record for "layer removed"

It's quite common for existing gravel wearing course layers to be virtually impossible to penetrate due to coarse aggregates and dryness of the layer. Therefore removing the layer, say 150-200 mm, would in many cases be the best option before proceeding with the test of the lower layers.

A facility for recording this in the data input screen and assigning a an assumed DN value for the layer removed would be handy, otherwise in extreme cases an entire section may be nealry impossible to test.

10. Example of User Defined Design Curve (for User Manaul)



TLC 0.3: DSN800 ≥ 100 (from DCP-DN Catalogue)
SPBC B=40

New User Defined Design Curve

Layer 1: Base 100 mm	DSN 0-100 = 43%	DN ≤ 100/43 = 2.3 mm/blow
Layer 2: Subbase 150 mm	DSN 100-250 = 29%	DN ≤ 150/29 = 5.2 mm/blow
Layer 3: Subgrade 150mm	DSN 250-400 = 14%	DN ≤ 150/14 = 11 mm/blow
Layer 4: Subgrade 200 mm	DSN 400-600 = 9%	DN ≤ 200/9 = 22 mm/blow
Layer 5: Subgrade 200 mm	DSN 600-800 = 5%	DN ≤ 200/5 = 40 mm/blow