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The African Community Access Programme (AFCAP)

DCP Pavement Design for
Low Volume Rural Roads Course

CSIR Pretoria, South Africa

August 31st - September 1st 2011

Note on the AFCAP DCP/Pavement Design for Low Volume Rural Roads Course at CSIR Pretoria, August 31st – September 1st 2011

1.0 AFCAP DCP COURSE AT CSIR

1.1 Introduction

The course on "*Low Volume Rural Road Pavement Design using the DCP"* was delivered by Dr. Phil Paige Green of CSIR. It covered the following aspects:

1. History and development of the DCP;
2. DCP equipment and its use;
3. Theoretical aspects of DCP related to pavement design;
4. The WinDCP software package;
5. Applications of DCP testing.

A brief overview of the main aspects of the course shall be given below. The general information on history and basics about the DCP equipment shall be omitted in order to keep the note brief.

1.2 Pavement Design

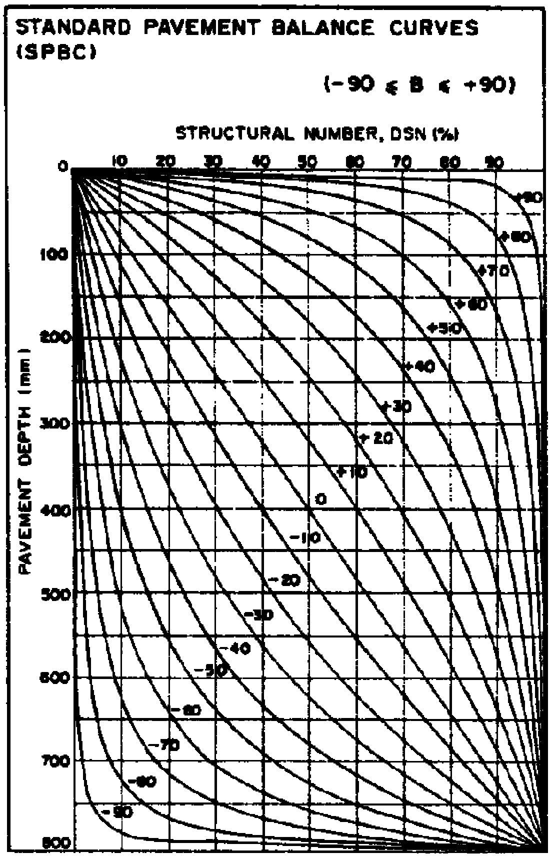
A brief overview of the basic principles of pavement design was given and issues such as traffic, materials and subgrade were discussed. Interesting observations were made by Mr. Pinard and Dr. Green about the overestimation of traffic and axle loading and how a damage exponent (n) of 4 can sometimes be too high for LVRR depending on the subgrade support that is available. If the pavement is "deep" and there is good structural support from the subgrade; it may be possible to use a lower damage exponent (n) as the pavement is less susceptible to damage from overloading.

The DCP design method uses the pavement strength balance concept – i.e. a well designed pavement should be well balanced and the loading should decrease progressively from surface to subgrade. A series of pavement balance curves have been developed and when DCP's are being analysed the results are compared to these standard curves to see which curve the existing pavement fits most closely (the WinDCP programme does this automatically).

The number of blows of the DCP required to reach a certain depth of the pavement expressed as a percentage of the DCP Structural Number (DSN_{800}) is called the Balance Number (BN). Pavements with a high BN are considered to be shallow, whilst those with a low BN are considered deep. As mentioned above, a shallow pavement is more susceptible to overloading than a deep one, thus requires a high damage exponent.

The pavement strength balance curves were used to develop a classification system. This utilises a graph with Structural Number (DSN) vs. Pavement Depth, upon which there are a number of standard curves plotted, as shown in Figure 1. The value "B" is that of the standard balance curve from the graph which is closest to the curve given by the DCP test. Value "A" is the deviation of the DCP measured curve from the standard curve. A low "A" value indicates a well balanced pavement – i.e. the balance curve from the DCP test fits closely to the standard one on the graph.

Figure 1 Standard Pavement Balance Curves[(1)]



[(1)]Source: Course notes by Dr. Phil Paige Green, CSIR, Pretoria.

The classification system is given below:

- Shallow Pavements: B ≥ 40 (BN ≥ 42%)
- Deep Pavements: 0 ≤ B < 40 (12.5% ≤ BN ≤ 42%)
- Inverted Pavements: B < 0 (BN < 12.5%)

- Well Balanced: 0 ≤ A ≤ 1200
- Averagely Balanced: 1200 < A ≤ 3000
- Poorly Balanced: A > 3000

1.3 WinDCP Software Package

The afternoon session covered the use of the WinDCP software package. DCP data can be entered into the program manually or via Excel and results can be shown individually, or in the case of project level analysis, they can be grouped to show them as average values for each section.

The software performs its calculations using weighted averages so that realistic values of penetration rates and CBR are determined. Older versions of the software used normal mathematical average values and when the differences in penetration were large, the results were not representative. For example, if the top 50 mm had a penetration rate of

1.5 mm per blow and the next 100 mm a rate of 6 mm per blow, the old version would have just taken an average of these two values, being 3.75 mm/blow. Using a weighted average, the value would be (1.5*50) + (4.5*100)/150 = 4.5 mm/blow. This value is higher and more realistic than that obtained using the normal average.

The program appears to be very useful, however, the one disadvantage it has is that you cannot vary the number of blows during a test, so the entire test must be carried out taking results after a set number of blows. Generally we would like to reduce the number of blows as the material gets weaker and this does not allow for that so you could miss weak layers if you are taking readings after every 5 blows for example.

2.0 SITE VISIT

The site visit was undertaken on the 31st of August and 1st of September. A number of roads were visited and various different surfacings were shown.

Typically the roads consisted of a lightly stabilised lateritic base with a bituminous seal. The stabiliser was either 1-2% cement or in some cases bituminous. All roads were constructed quite recently – year of construction was around 2007 so within the last 4 years or so.

The seals varied between single Otta seals, modified Otta seals, premix and cape seal. In general the roads were still in good condition with few visible signs of serious deformation. In some areas there was evidence of cracking which was beginning to occur, typically in the wheel paths. This may have been due to the materials or construction quality but in some cases was due to poor adhesion between the surfacing and base layer – when hit with a small hammer a hollow sound could be heard.

However, overall the road condition was good and the roads were still performing well. The single Otta seals seemed to be performing very well and were probably the cheapest surfacing of all those used. Some put this down to the flexibility and the use of soft bitumen which provided some self-healing properties, sealing any small cracks.

Another issue which was brought up for future consideration was drainage. One of the roads visited was constructed on a hill and had extensive stone-pitch lined drains down one side. Whilst these added greatly to the cost of the road, it was pointed out that drainage is an absolutely necessary component of the design and something which has not always been given enough consideration on LVRR.

3.0 CONCLUSION

The course was a very worthwhile experience and provided a lot of expert opinions from people such as Dr. Green and Mr. Pinard on their experiences designing and constructing LVRR. It provided useful insights into methods which will be used on other AFCAP projects and which should be incorporated into other LVRR designs elsewhere – possibly even a current project we are working on in Northern Zambia

There were a number of valuable points made throughout the 3 days, especially in relation to selection of the various design parameters and the use of engineering judgement in your designs rather than relying on traditional design manuals.

Some of the most interesting points related to:

- The over-estimating of axle loading as in some case an exponent of 4 can be too high;
- The DCP design method and the pavement balance strength concept;
- The fact that the environment has a greater impact on LVRR than traffic;

- Designing adequate side drainage and use of a drainage factor which is >7.5 – something outlined by Mr. Pinard from experiences in Malawi. The distance from the road centreline to the drain multiplied by the height from the crown to the bottom of the drain should be 7.5 or greater to provide a free draining pavement;
- Compaction levels – the CBR which can be obtained from a material varies greatly depending on the compaction level, so consider using higher compaction efforts to achieve higher CBR values;
- Traditional design parameters such as PI – the CBR of the material is the important factor, if the PI is a little high it is not always critical once the material can remain relatively dry. Some low volume roads from Malawi were shown during the presentation by Mr. Pinard. These had high PI values, some up to 16%, in the base and are still in good condition;
- Similar to the above comment, the use of tradition design standards and design methods can greatly overdesign LVRR. Use of engineering judgement and knowledge of local materials and their performance when designing the pavement is required to construct LVRR in a cost effective manner.