CHAPTER 3

IN SITU PAVEMENT CLASSIFICATION SYSTEM BASED ON THE RESULTS OF THE DYNAMIC CONE PENETROMETER (DCP)

CONTENTS PAGE

3.1 INTRODUCTION

The Transvaal Provincial Administration (TPA) initiated the application of the Dynamic Cone Penetrometer (DCP) to evaluate in situ structural conditions of their pavements during the early 1970s. Over the past few years, the DCP has established itself as a valuable pavement design and evaluation tool in South Africa and elsewhere (Kleyn, 1984, Kleyn et al, 1982a; 1982b; 1982c; 1987; Livneh et al, 1987; Chua, 1988).

The DCP is mainly used on pavements with unbound granular and lightly cemented layers (7-day soaked Unconfined Compressive Strength (UCS) $\leq$ 4 MPa). The majority of roads in the developing countries in Southern Africa fall into this category. Bituminous surfaced roads comprise approximately 25 per cent of the total road network in these developing countries. In the province of the Transvaal, more than 80 per cent of the pavements incorporate lightly cementitious layers. For these countries, including South Africa, to continue to develop towards their full potential, improvements to their road networks are necessary. This is normally done by upgrading existing pavements, constructing new ones and rehabilitating bituminous - surfaced pavements which have reached the end of their design life. Experience to date indicates that the potential use of the DCP is very high on both unbound gravels and lightly cementitious materials and that very useful information regarding the behaviour of pavements and pavement definition is obtained with the DCP. In a recent study Chua (1988) indicated that the determination of the in situ elastic moduli (effective elastic moduli) is also possible using the DCP. However, it is my opinion that there is a need for objective methods for analysing DCP results in general, and furthermore, to explain basic pavement behaviour, also under accelerated testing. A standardised output format is also needed.

During the initiation of this study, the above mentioned problem was identified as one of the most important aspects to be adressed <u>before</u> proper use could be made of the DCP results, especially in association with the research with the Heavy Vehicle Simulator (HVS) regarding pavement behaviour. It was considered that a standard method could be developed against which all DCP results should be evaluated. It is my opinion that such a system should form the corner stone of the analysis of DCP results in future, even on pavements without lightly cementitious layers.

In this chapter the development of a universal pavement strength - balance classification system based on DCP results, is discussed. As mentioned, until this study, no generally accepted method for classifying DCP data existed and such a classification system, similar to some well - known soil classification systems (Lambe et al, 1969; Scott, 1974), is much needed to enhance the interpretation of DCP results. Such a classification system will also increase objectivity in the classification, interpretation and comparison of DCP results. This will not only enhance the use of the DCP instrument, but also the understanding of in situ pavement definition and basic pavement behaviour, especially amongst inexperienced users of the DCP.

Most of the DCP results discussed in this chapter originated from tests on pavements with lightly cementitious layers, but the principles discussed here are also generally applicable to unbound granular pavement types. At this stage, however, bituminous and concrete base pavements are excluded from this analysis. After a discussion of the pavement strength - balance concept, the classification system is presented. Various examples are given to illustrate the different DCP categories in which pavements can be classified in according to this system.

In Chapter 6, a detailed analysis, based on this classification system, of the DCP results measured on pavements with cementitious layers evaluated during this study, is discussed.

3.2 THE CONCEPT OF PAVEMENT STRENGTH - BALANCE

3.2.1 Background

Fundamentally, the strength - balance of a pavement structure is defined as the change in the strength of the pavement layers with depth (Kleyn et al, 1982a, 1982b, 1982c, Kleyn, 1984). Normally, the strength of the pavement decreases with depth and, in principle, if this decrease is smooth and without any severe discontinuities, the pavement is regarded as balanced or in a state of balance.

The development of the strength - balance concept of pavements, including the Standard Pavement Balance Curves (SPBCs), however, originated from numerous DCP results obtained on unbound granular type pavements (Kleyn et al, 1987). The name Standard Pavement Balance Curves (SPBCs) in this dissertation is used instead of the name Pavement Strength - Balance Curves, which is used in most the references indicated above. This was necessary to distinguish between a balance curve described by the BN, and the balance curve described by the B parameter (For definition of parameters B and BN see following paragraphs, and Paragraph 3.2.2, as well as the above mentioned references in this paragraph).

With respect to the DCP, the average rate of penetration (DN, in mm per blow) through the various pavement layers, is proportional to the in situ shear strength of the material and is correlated to the California Bearing Ratio (CBR) or UCS of the material. It is therefore considered that layers of relatively high and relatively low strength, respectively, will be distinguished from each other. Not only will the rates of penetration of the individual layers be known, but also the strength relations between the different layers within the total pavement structure. From this knowledge, the balance of the pavement can be evaluated.

During the development of the pavement strength - balance equations (Kleyn et al, 1987), a simple formula, describing the relation between the pavement structure number, DSN in %, the pavement depth, D in % and a parameter, B, describing the SPBCs, was obtained. According to Kleyn et al (1987), it was found that the equation for a rectangular hyperbola describes remarkably well the strength balance of the pavements tested. According to this equation, there are, in theory, an infinite number of SPBCs for flexible pavement structures with relatively thin surfacings (< 50 mm), and is used as a basis for the pavement strength - balance classification system, described in this chapter. The formula is given below :

$$DSN\ (\%) = \frac{D*[400*B + (100 - B)^2]}{4*B*D + (100 - B)^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

where : DSN = pavement structure number, as percentage (%)

B = parameter, defining the standard pavement balance curve (SPBC)

D = pavement depth, as percentage (%)

In Figure 3.1, a graphic illustration of this formula is given and show two curves from a family of balance curves. These curves indicates that the pavement strength decreases with pavement depth. If B = 0, the balance curve (SPBC) is a straight line from DSN = 0 per cent to D = 100 per cent.

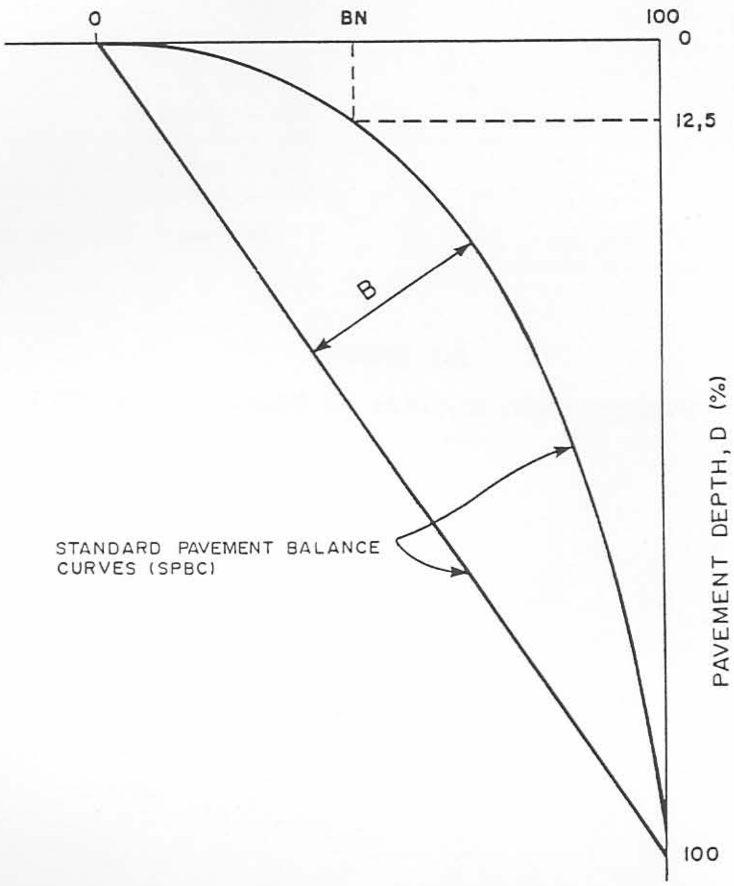
Normally, the **total number of blows** needed to penetrate the total pavement depth, say 800 mm, is indicated as **DSN_{800}**, in **blows**. As indicated earlier, there are an infinite number of balance curves (SPBCs), and balance curves other than those discussed above can be obtained graphically by interpolation or by calculation using Equation 3.1.

In Figures 3.2(a), 3.2(b), 3.2(c) and 3.2(d), typical examples of various DCP results, plotted in the format discussed above, are indicated. In Figure 3.2(a) an example of a **balanced pavement structure** is illustrated, while in Figures 3.2(b) and 3.2(d) examples of **unbalanced pavements** are shown. The **imbalance** is indicated by the deviation of the **DCP data** (DSN data, as a percentage) from the **SPBCs**, which will be discussed in Paragraph 3.2.4 in more detail. Although the **normal case** is that pavements **decrease in strength** with **depth (B $\geq$ 0)**, as is illustrated in Figure 3.2(a),(b) and (d), pavements can also **increase in strength** with **depth (B < 0)** as is illustrated in Figure 3.2(c) and are normally refered to as "upside down" or inverted pavement structures.

3.2.2 Parameter B versus BN

The parameter B varies, in theory, from - 100 to + 100, which ultimately defines **comprehensive SPBCs** in this dissertation. The SPBCs with B < 0 is a mirror image of the SPBCs where B > 0, as is illustrated in Figure 3.3, for a pavement depth (PD) of 800 mm. In this figure, parameter B varies between -90 and +90, with intervals of 10 units between individual curves. In this approach **the parameter B is used to define the various SPBCs**, and is different from that used by Kleyn et al (1988), where the **Balance Number, BN, (BN = DSN in per cent at D = 12,5 per cent)** is used. The selection of B in this dissertation instead of BN to define the balance curves, however, was necessary to develop the classification system, firstly, because of its simplicity, as expressed in previous Equation 3.1, and secondly, that BN defines only a single point on the full balance curve of the pavement while B defines the curve for the full pavement depth. The BN only defines the balance curve accurately <u>if the pavement is perfectly balanced</u>, which, however, is not the normal case for most pavements and another more relevant parameter is needed.

THE FORMULA FOR STANDARD PAVEMENT BALANCE CURVES*



(NOT TO SCALE)

$$^{*}DSN\ (\%) = \frac{D\left[400B + (100-B)^2\right]}{4DB + (100-B)^2}$$

FIGURE 3.1

GRAPHIC REPRESENTATION OF THE FORMULA FOR STANDARD PAVEMENT BALANCE CURVES (SPBC)

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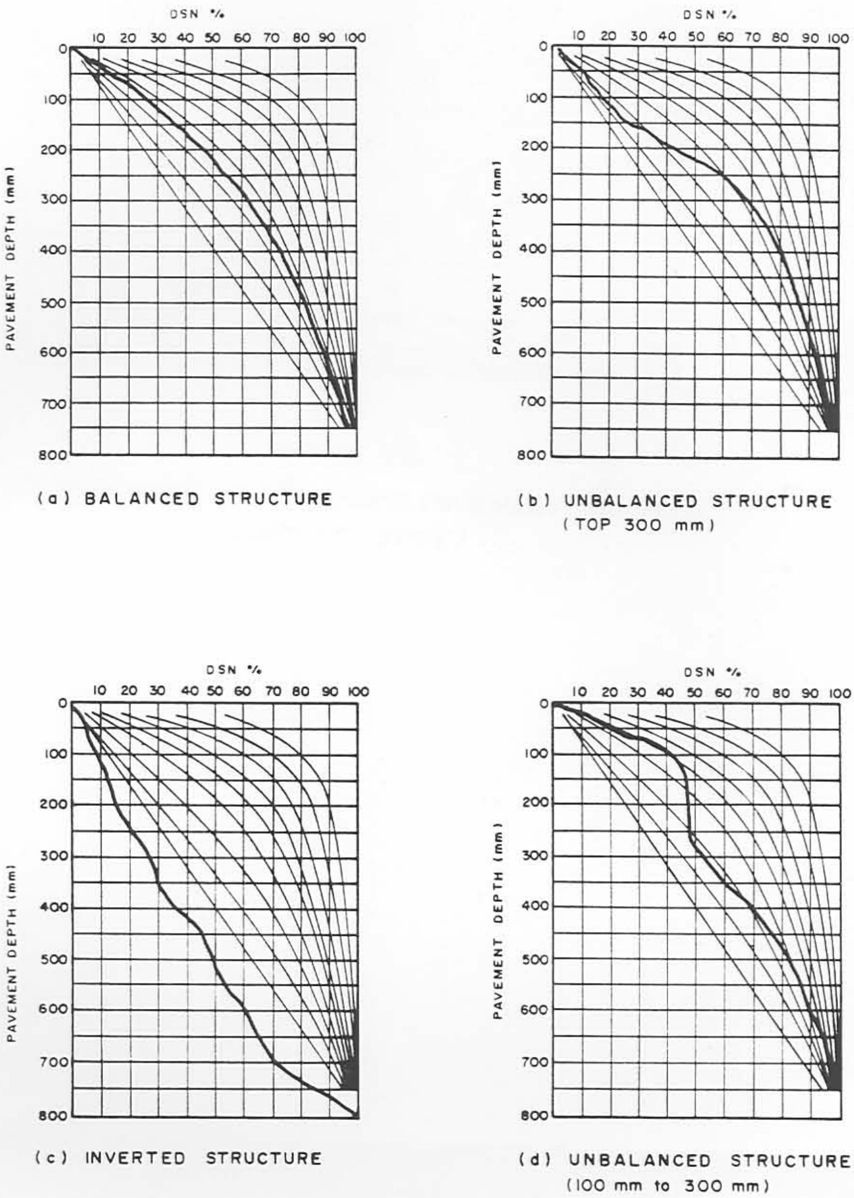

FIGURE 3.2

TYPICAL EXAMPLES OF VARIOUS DCP-RESULTS

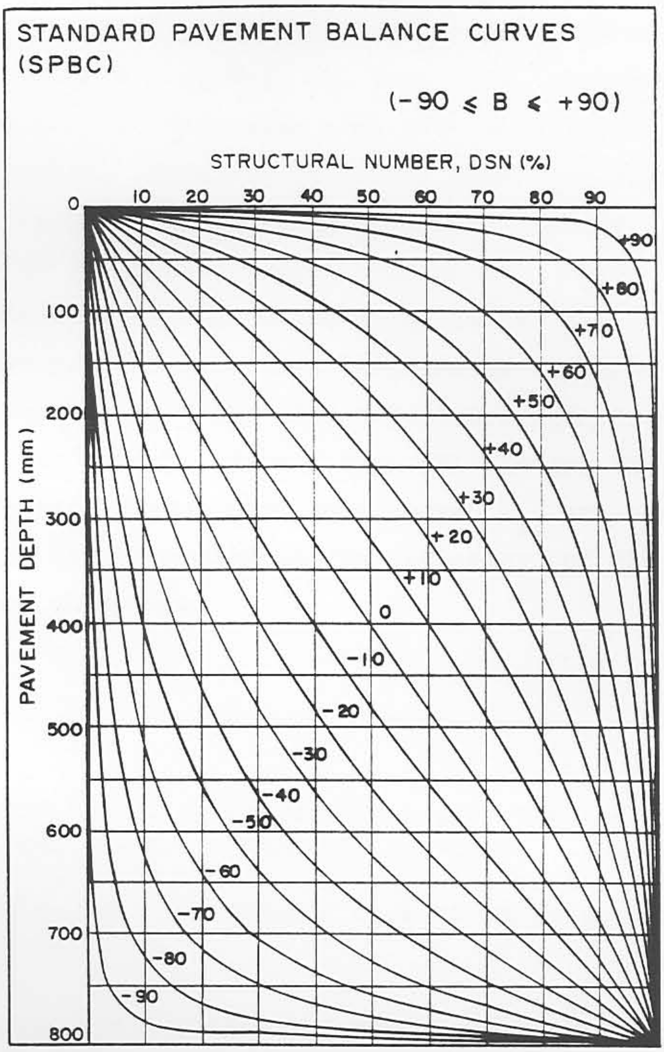

FIGURE 3.3

COMPREHENSIVE STANDARD PAVEMENT BALANCE CURVES (SPBC)

940-4-5729/3 BD

Inspection of the given formulation (Equation 3.1) then revealed the use of B, instead of BN, because B describes the total balance curve, which may then be assigned to a pavement, and is used in this dissertation to characterise the "deepness" or "shallowness" of the pavement.

3.2.3 Deviation from SPBCs

It must, however, be remembered that both B and BN fail to indicate or quantify deviations in the strength balance of the pavement from the idealised balance curve (SPBCs). This leads to the additional requirement for the classification system that the state of the balance (deviation from SPBC) of the pavement has to be quantified, because most of real pavements are not perfectly strength - balanced. The original method only provides for strength - balanced pavements (Kleyn et al, 1988). In order to quantify the deviation in the strength - balance of real pavements from the SPBCs, the deviation (area) between the best fit SPBC for the data, and the actual data (DSN data), is used. In Figure 3.4, the method for calculating this deviation in terms of area A_i, is illustrated.

3.2.4 Best fit SPBC

The total area (A) between the DCP data and a series of SPBCs is calculated, and the SPBC resulting in the minimum area is then assigned to the pavement. This "best fit" SPBC* is then regarded as unique to that data (pavement) under consideration. Figure 3.4 indicates that the best fit SPBC for the DCP data indicated in the figure, is where B = 38. The absolute (mod) area (A) is calculated in a discrete order by calculating the difference between the DSN of the SPBC and the DSN of the DCP data (DSN data). This is done at different depths in the pavement, using increments of 8 mm in this case. These differences are then used to calculate the area of a trapezoid with a width of 8 mm, and at both sides of the SPBC. Per definition, the areas to the left of the SPBC are negative, but this is ignored when calculating the total area, A (see Equation 3.2). Finally, these individual areas, A_i, are added together and the sum of the areas (A) is then used as the indicator of the state of balance of the in situ pavement structure.

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* The "best fit" SPBC is not always the "average" SPBC of the data, and differs slightly on well and averagely balanced pavements. This difference, however, increase markedly with an increase in imbalance or A. The advantage of the "best fit" method is that deviations from the SPBC is more accentuated.

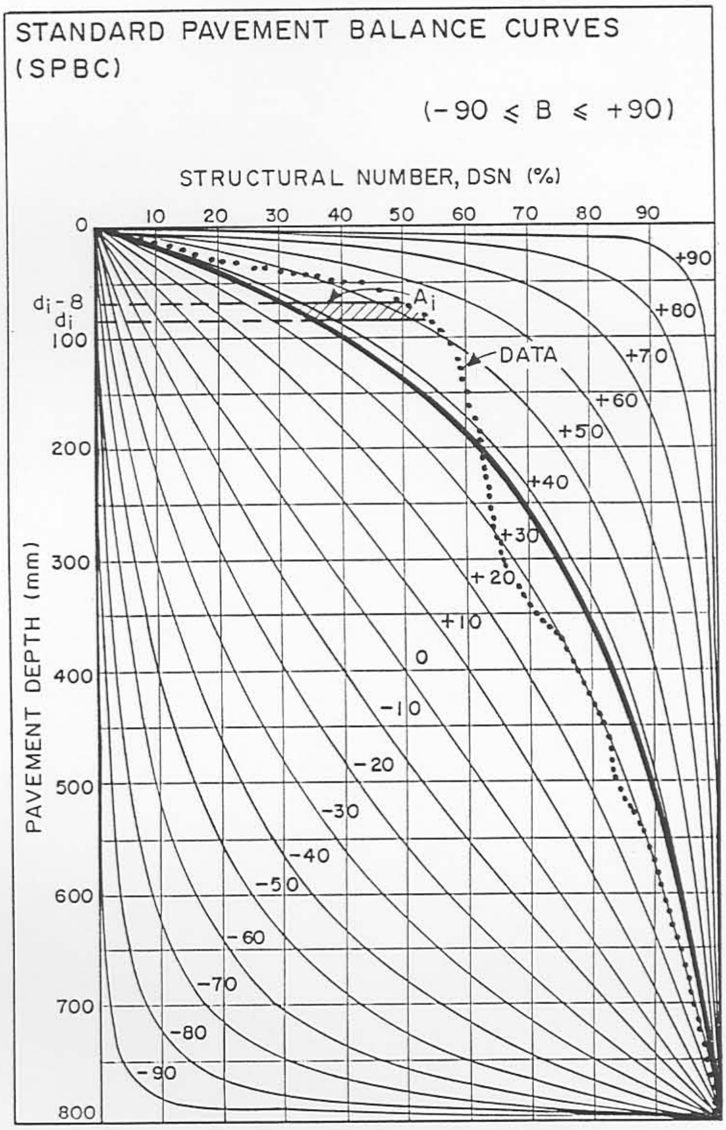


FIGURE 3.4

CALCULATION OF THE DEVIATION (AREA) OF THE DCP-DATA FROM THE STANDARD PAVEMENT BALANCE CURVES (SPBC)

For a pavement depth of 800 mm, the sum total of the absolute areas is as follows:

$$\text{AREA (A)} = \sum_{i=1}^{100} |A_i| \qquad \text{......3.2}$$

where A is %.mm

For a perfect strength - balanced pavement, the area A = 0. This means that the deviation (area) between the DCP data balance curve and the "best fit" SPBC of the data, is equal to zero.

From the discussion above it is evident that the two distinct parameters, B and A, are used to define the DCP data. These two parameters, therefore, form the basis for the proposed pavement strength - balance classification system, which will be described in the next section.

3.3 PAVEMENT STRENGTH - BALANCE CLASSIFICATION SYSTEM

3.3.1 Analysis of some DCP data

Following the definition and description of the two unique parameters, B and A, an analysis of approximately 275 DCP measurements was carried out on both lightly cemented and granular base pavement structures. Figure 3.5 gives the various DCP data, indicating the spread in terms of balance (B) and deviation from balance (A). These DCPs were measured mainly on three different pavements: on Road 1932 and Road 2212, north of Pretoria, where extensive Heavy Vehicle Simulator (HVS) tests were recently done, and on granular pavements in the Benoni area.

The figure indicates that parameter B varies between approximately -20 and +60, and parameter A between 600 and 8000 %.mm. The figure also indicates that the centre of gravity of the two sets of data for the cemented roads (1932 and 2212) is at different locations in terms of parameter B, but with approximately the same deviation from the balance, parameter A. This is an indication that the relative strength distribution in the layers of these two pavements is different.

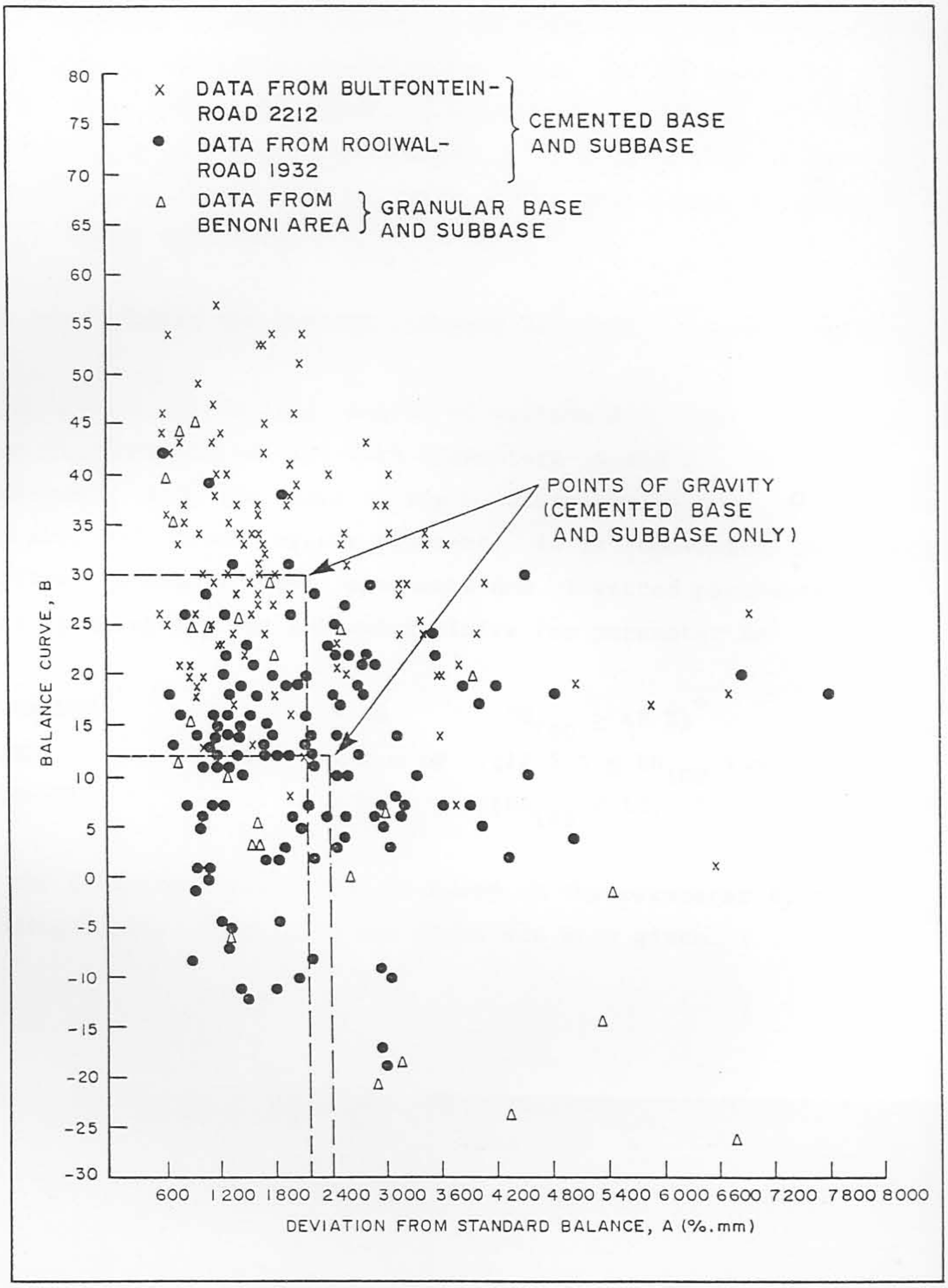


FIGURE 3.5

VARIOUS DCP-DATA INDICATING THE SPREAD IN THE RESULTS IN TERMS OF BALANCE AND DEVIATION FROM THE STANDARD PAVEMENT BALANCE CURVES

940-4-5729/5 BD

For Road 2212, with an average B value of 30, the upper pavement layers (base and subbase), contribute relatively more to the total pavement strength, in terms of total number of blows to penetrate the full pavement depth, than the lower layers. For Road 1932, however, with an average B value of 12, there is a relatively greater contribution by the lower layers to the total pavement strength. Thus the higher the value of B parameter, the greater the contribution to the total strength from the upper layers, and vice versa. From this example it is clear that the higher the B parameter the "shallower" the pavement structure and the lower the B parameter the "deeper" the pavement structure. This is analogous to BN used by Kleyn et al (1988), for the same purpose. Although most of the above data originated from pavements incorporating lightly cemented layers, parameters B and A of unbound granular pavement types also fall between the following limits:

$$-90 \leq B \leq +90 \quad \text{and}$$

$$0 \leq A \leq 10\ 000$$

As indicated earlier, positive B values (or BN ≥ 12,5 %) are indicative of pavements decreasing in strength with depth, as is the case for most of the DCP data. On the other hand, negative B values (or BN < 12,5 %) are indicative of pavements increasing in strength with depth. This is generally the case where relatively weak upper layers and/ or rocky underlying layers are present within the defined pavement structure.

3.4 LIMITS FOR DEFINING THE VARIOUS PAVEMENT STRENGTH - BALANCE CATEGORIES

From experience with the balance curves of various DCP data it was decided to define three distinct ranges for both parameters A and B. In order to group together pavements with the same strength distribution from the top of the pavement to the full depth of the pavement, it is convenient to distinguish between shallow pavements, deep pavements and inverted pavements. This was accomplished by selecting the following limits for parameter B:

SHALLOW PAVEMENTS	:	$B \geq 40$	;($BN_{100} \geq 42$ %)*
DEEP PAVEMENTS	:	$0 \leq B < 40$	;(12,5 % $\leq BN_{100} <$ 42 %)
INVERTED PAVEMENTS	:	$B < 0$	;($BN_{100} <$ 12,5 %)

* Although the classification system is based on the parameter B, the corresponding limits in BN_{100} of the SPBCs are also given.

In order to group pavements with the same state of "balance" together, it is convenient to distinguish between well - balanced, averagely balanced and poorly balanced pavement structures by selecting the following limits for parameter A:

WELL - BALANCED	:	$0 \le A \le 1200$
AVERAGELY BALANCED	:	$1200 < A \le 3000$
POORLY BALANCED	:	$A > 3000$

These limits are illustrated in Figure 3.6, where they have been superimposed on the previous DCP data from Figure 3.5. Figure 3.6, with these limits, but without the DCP data, represents the pavement strength - balance or DCP classification sheet. By means of this approach, nine distinct pavement strength - balance or DCP categories are defined. These categories are summarised in Table 3.1.

TABLE 3.1 DEFINITION OF THE NINE DIFFERENT PAVEMENT STRENGTH - BALANCE CATEGORIES

LIMITS FOR PARAMETERS B AND A		DESCRIPTION OF CATEGORY
$B \ge 40$ $0 \le A \le 1200$;	(I)	WELL - BALANCED SHALLOW STRUCTURE (WBS)
$B \ge 40$; $1200 < A \le 3000$;	(II)	AVERAGELY BALANCED SHALLOW STRUCTURE (ABS)
$B \ge 40$; $A > 3000$;	(III)	POORLY BALANCED SHALLOW STRUCTURE (PBS)
$0 \le B < 40$; $0 \le A \le 1200$;	(IV)	WELL - BALANCED DEEP STRUCTURE (WBD)
$0 \le B < 40$; $1200 < A \le 3000$;	(V)	AVERAGELY BALANCED DEEP STRUCTURE (ABD)
$0 \le B < 40$; $A > 3000$;	(VI)	POORLY BALANCED DEEP STRUCTURE (PBD)
$B < 0$; $0 \le A \le 1200$;	(VII)	WELL - BALANCED INVERTED STRUCTURE (WBI)
$B < 0$; $1200 < A \le 3000$;	(VIII)	AVERAGELY BALANCED INVERTED STRUCTURE (ABI)
$B < 0$; $A > 3000$;	(IX)	POORLY BALANCED INVERTED STRUCTURE (PBI)

In Figures 3.7(a) and 3.7(b), various examples of the different categories are shown. These figures should be read together with Table 3.1. In Figure 3.8, the examples illustrated in Figures 3.7(a) and 3.7(b) are indicated on the DCP classification sheet.

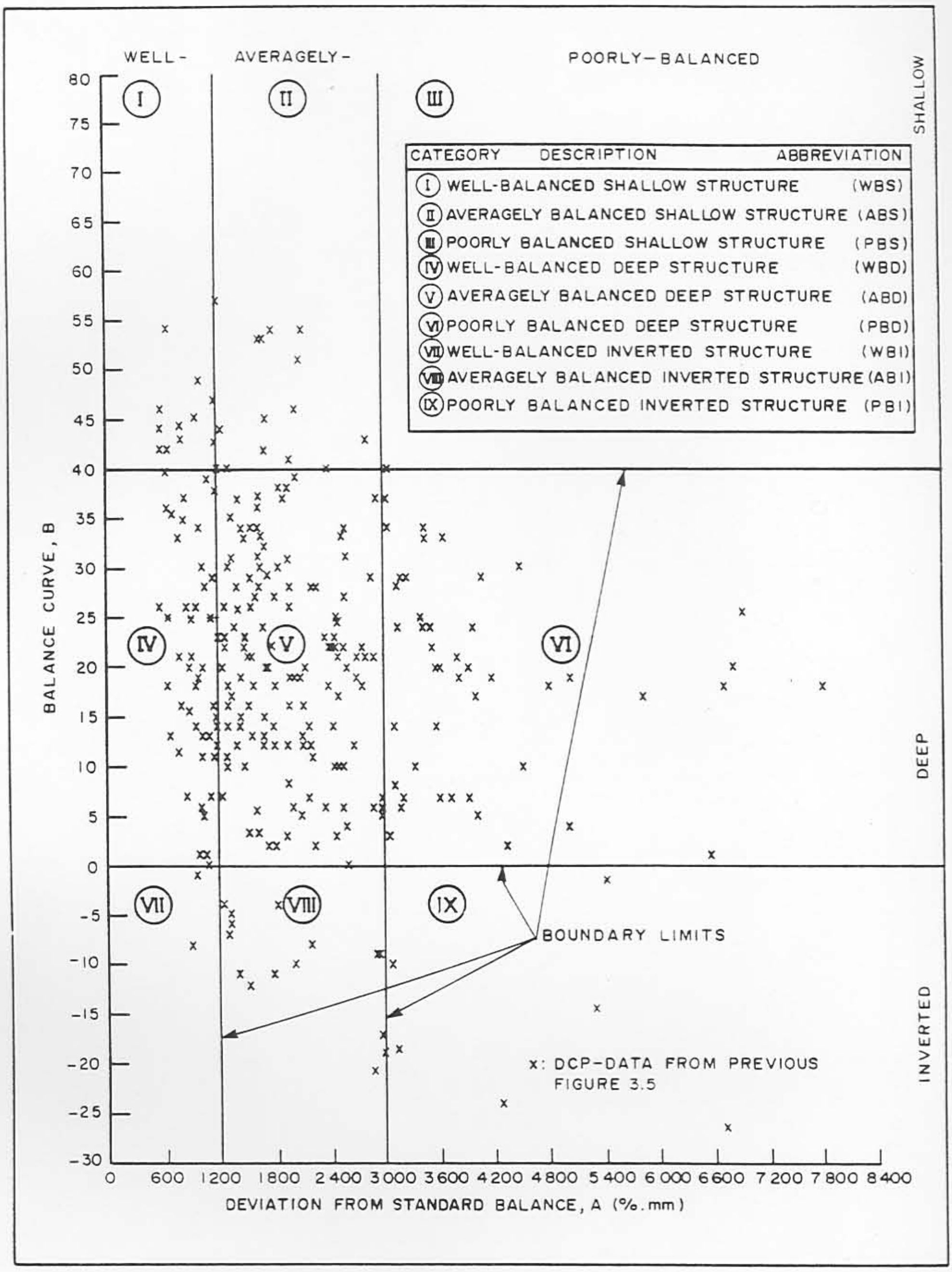
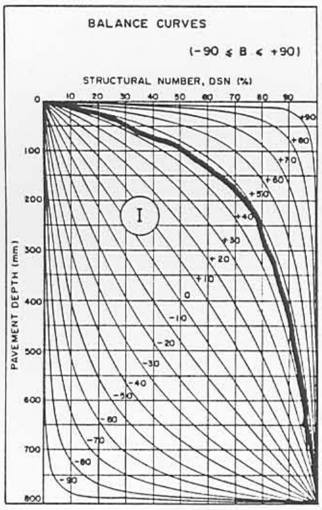


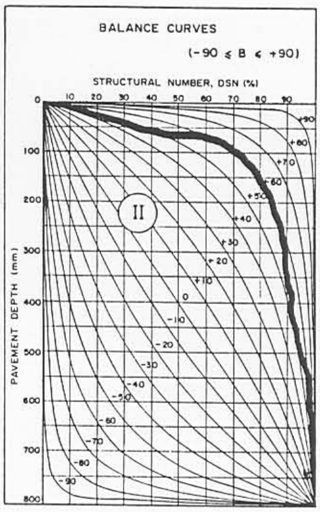
FIGURE 3.6

CLASSIFICATION LIMITS IN THE A AND B-PARAMETERS DEFINING THE NINE DIFFERENT CATEGORIES FOR THE DCP-DATA

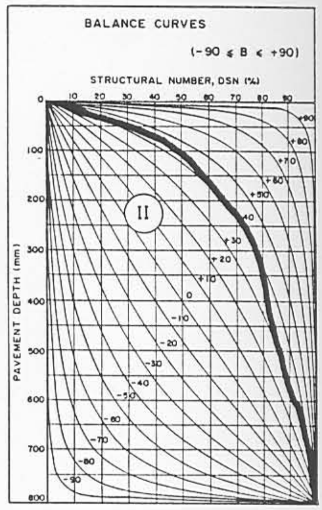
940-4-5729/6 BD



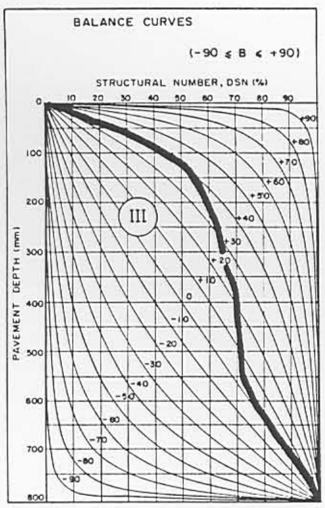
(a) WELL-BALANCED SHALLOW (WBS)



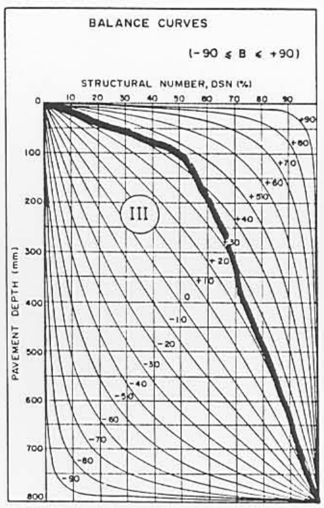
(b) AVERAGELY-BALANCED SHALLOW (ABS)



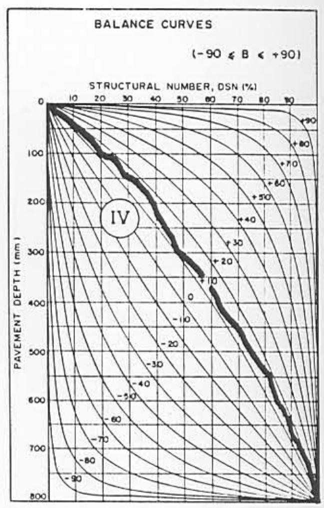
(c) AVERAGELY-BALANCED SHALLOW (ABS)



(d) POORLY-BALANCED SHALLOW (PBS)



(e) POORLY-BALANCED SHALLOW (PBS)

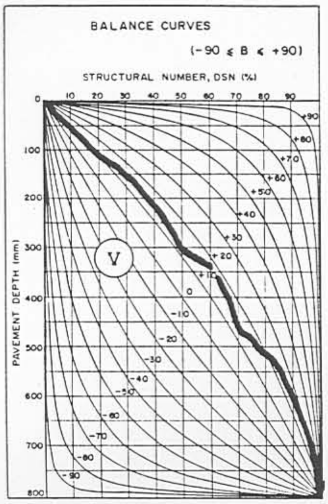


(f) WELL-BALANCED DEEP (WBD)

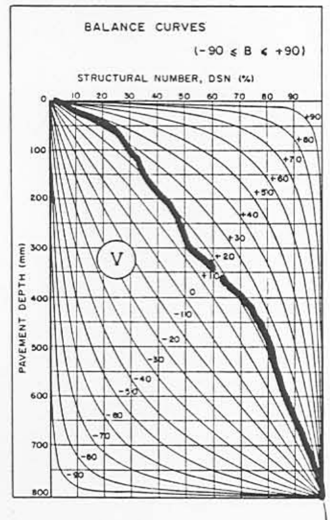
(I) : DCP CATEGORY

FIGURE 3.7(a)

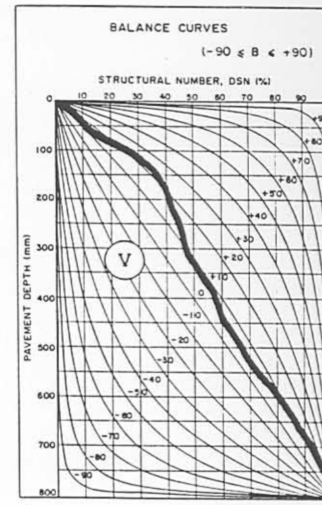
EXAMPLES OF DIFFERENT DCP CATEGORIES



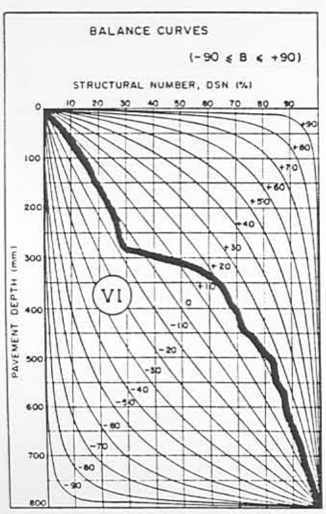
(a) AVERAGELY - BALANCED DEEP (ABD)



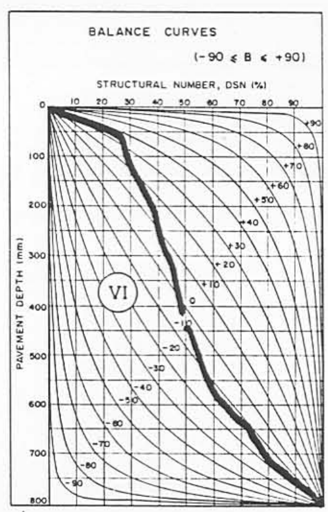
(b) AVERAGELY- BALANCED DEEP (ABD)



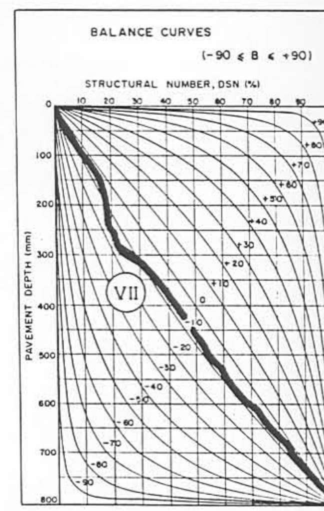
(c) AVERAGELY- BALANCED DEEP (ABD)



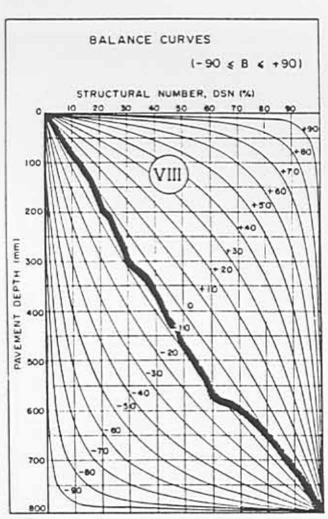
(d) POORLY - BALANCED DEEP (PBD)



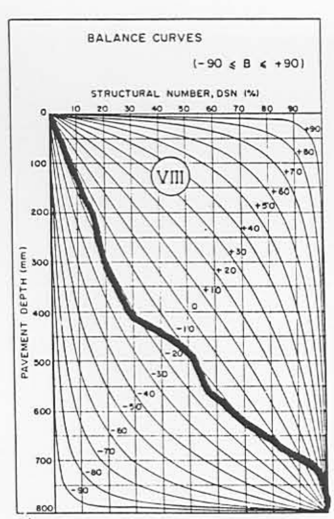
(e) POORLY - BALANCED DEEP (PBD)



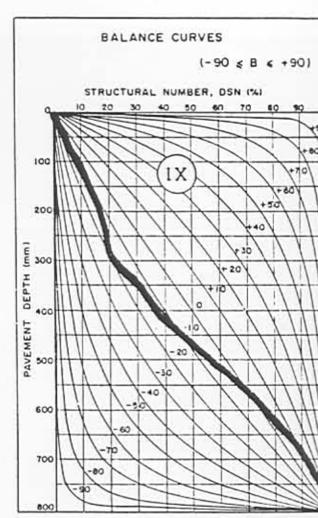
(f) WELL- BALANCED INVERTED (WBI)



(g) AVERAGELY-BALANCED INVERTED (ABI)



(h) AVERAGELY - BALANCED INVERTED (ABI)



(i) POORLY - BALANCED INVERTED (PBI)

(V) : DCP CATEGORY

FIGURE 3.7(b)

EXAMPLES OF DIFFERENT DCP CATEGORIES

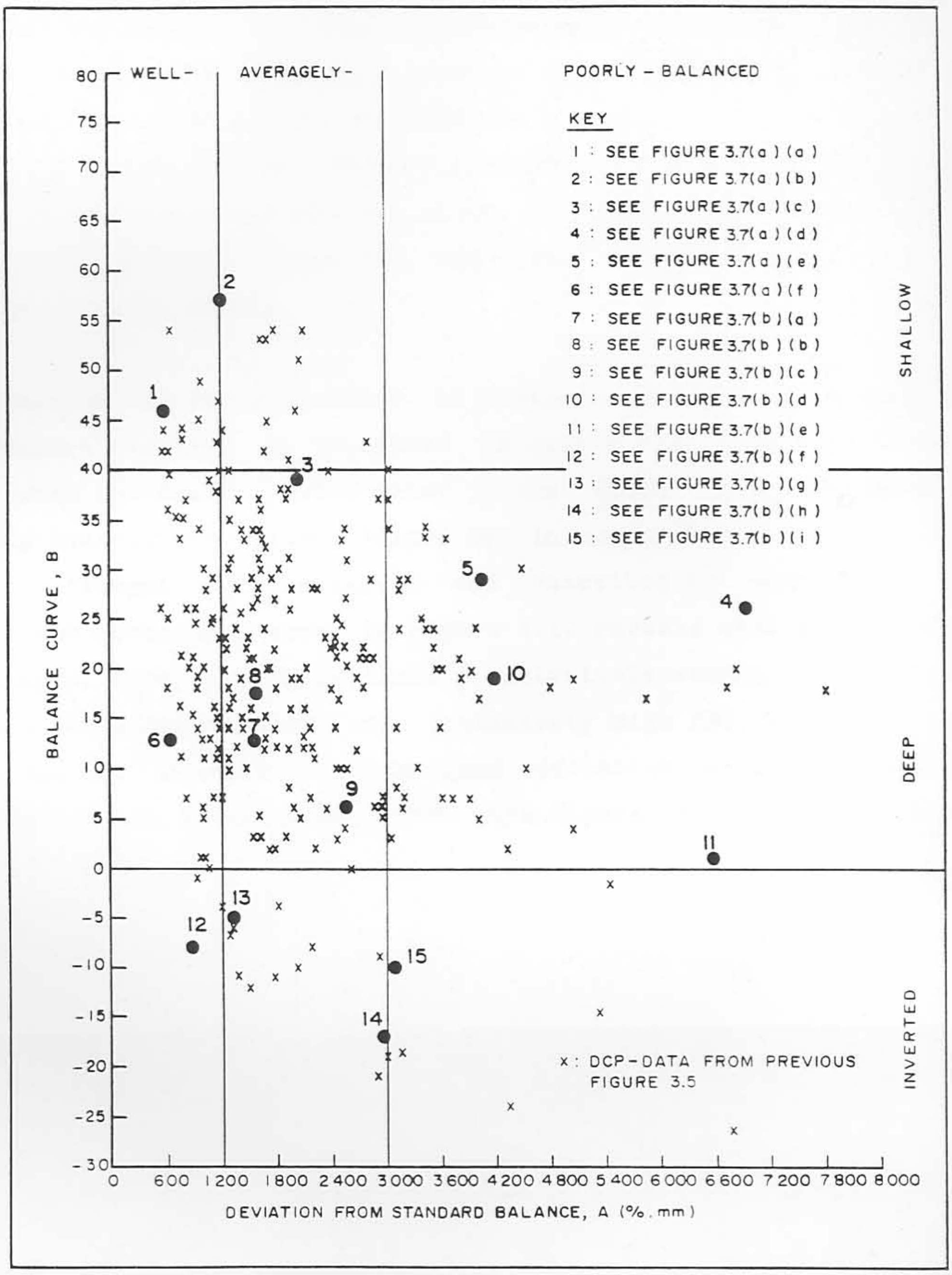


FIGURE 3.8

EXAMPLES OF THE DIFFERENT DCP-CATEGORIES ON THE DCP-CLASSIFICATION SHEET

3.5 INFERENCES FROM THE DCP DATA IN TERMS OF BALANCE

With the pavement strength - balance classification system defined, it is also possible to locate deviations in the balance of the pavement structure. This is accomplished by studying the balance curve of the data in relation to the "best fit" SPBC for the same data. In Figure 3.9 an example of DCP data and the related SPBC, B = 43, is illustrated. The figure shows relatively large deviations of (parameter A) the data from the related SPBC at depths of approximately 80 mm and 210 mm. There are discontinuities in the pavement structure at these depths. Normally this occurs when a relatively strong layer overlies a relatively weak layer, or vice versa. When parameter A_i increase towards the right of the SPBC, this is indicative of a relatively strong layer over a relatively weak layer, and vice versa if A_i decrease towards the left of the SPBC. These relative changes in A_i may occur on the positive side, both positve and negative, or the negative side of the SPBC (See Figures 3.10 and 3.11, later).

To distinguish more accurately between the layer interfaces, i.e. where these discontinuities occur within the pavement structure, a normalized curve of the deviations, A_i, at different depths in the pavement is compiled. The normalized curve for the DCP data of Figure 3.9, is illustrated in Figure 3.10. The figure shows that the deviations, A_i, vary with pavement depth, and can be either positive, zero or negative. Further, maximum and minimum values for parameter A_i reflect discontinuities within the pavement structure. The interfaces of the different in situ layers in the pavement structure are therefore defined by the depths where these maximum and minimum values for parameter A_i occur. By means of this approach, new layer thicknesses are defined on the basis of the relative strength of the in situ layers.

This is very useful in the evaluation of pavement structures, as the in situ pavement structure (layers) in the field is seldom the structure (layers) as designed, or what one assumes will exist in the field. Also indicated in the figure are the average penetration rates, DN, in mm per blow, for the different layers. The "strength" of the layers are described by their DN - values. Inspection of the normalized curve in Figure 3.10 reveals that an increasing and then decreasing A, with depth, reflects a relatively strong layer (relatively low DN) upon a relatively weaker layer (relatively high DN), and vice versa. In Figure 3.11, various examples of normalized deviation curves on Road 2212 at Bultfontein (Tvl), are illustrated. From this figure the variations in

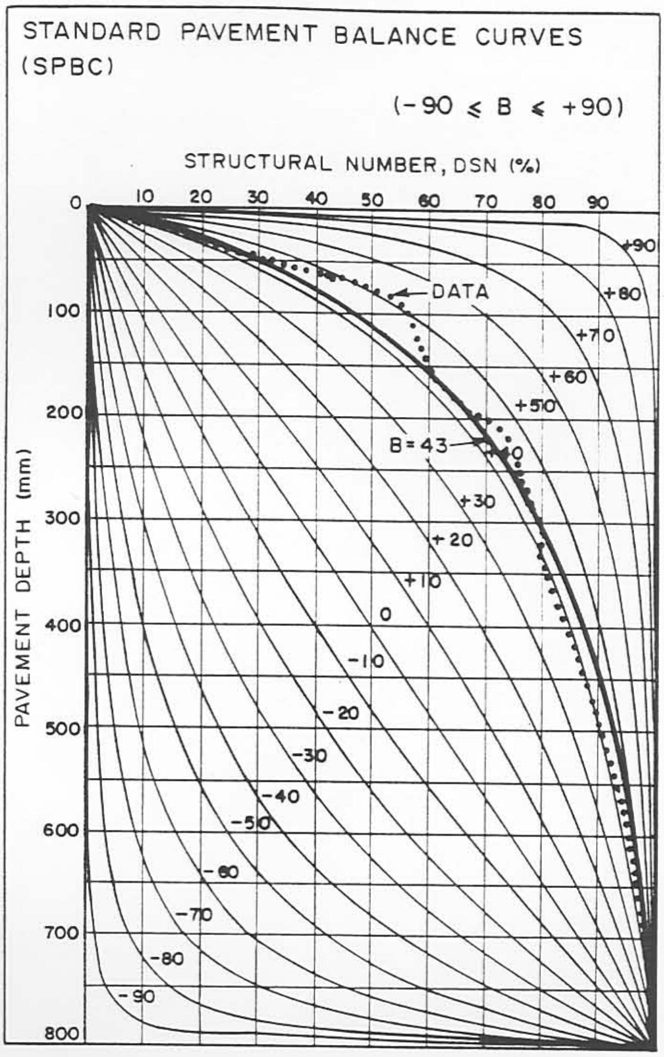


FIGURE 3.9

EXAMPLE OF DCP-DATA AROUND THE STANDARD PAVEMENT BALANCE CURVE, B = 43, FROM WHICH NORMALIZED CURVES OF THE DEVIATION ARE DRAWN

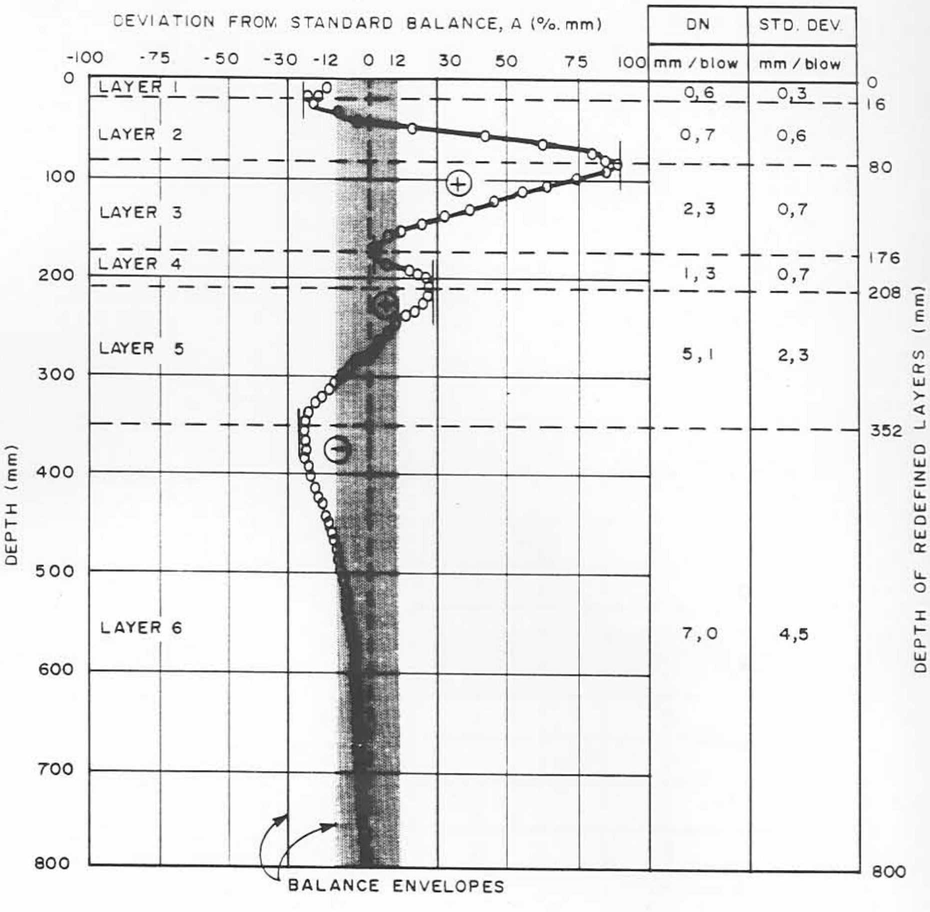


FIGURE 3.10

NORMALIZED CURVE OF THE DEVIATION (A) VS PAVEMENT DEPTH OF DCP-DATA FROM THE STANDARD PAVEMENT BALANCE CURVE, B=43

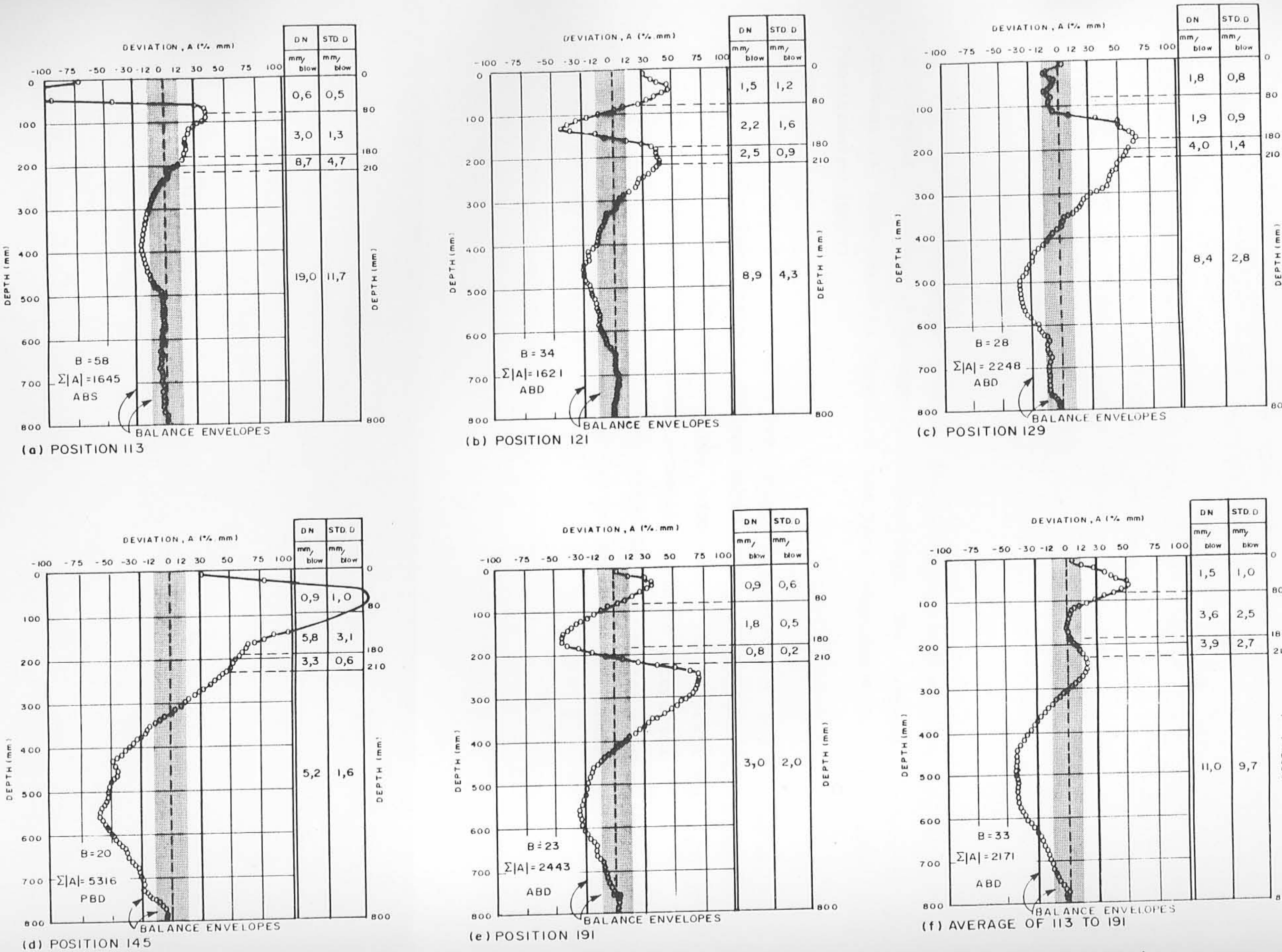


FIGURE 3.11 *VARIOUS EXAMPLES OF NORMALIZED DEVIATION CURVES ON ROAD 2212 AT km 12,65 (BULTFONTEIN, TVL)*

composition of the "same" pavement, as measured with the DCP, are obvious. This is very important information, not only for the analysis of basic pavement behaviour, but also for pavement rehabilitation design.

3.6 DCP COMPUTER PROGRAMS

Two **DCP computer programs** to evaluate the DCP data have been developed at the Division for Roads and Transport Technology. The names of these programs are **DCPB** and **AVEB** and they can be run on IBM compatible personal computers.
The program **DCPB** is used to evaluate DCP data measured at a **single** position, while program **AVEB** is used to evaluate the average of up to **50 individual** DCP **measuring positions**. Both programs calculate average penetration rates through the pavement for the different layers, including certain percentile values, depending on the category of the road under consideration.

The **pavement strength - balance classification** is done automatically, as is an evaluation of the **state of balance** including the **redefinition** of the thicknesses of the layers based on in situ measured strength.

In Appendix C the users manual, the data input as well as the output format of the various DCP programs are given. In Chapter 6 as well as in Appendix E, examples of the graphical output of the pavements studied in this dissertation using these programs, are also given.

3.7 SUMMARY AND CONCLUSIONS

In this chapter a **universal pavement classification system**, based on the **concept of strength - balance of pavements**, is described. The **strength - balance** of the pavement is calculated by means of the data obtained with the **Dynamic Cone Penetrometer (DCP)**.

This **classification** is based on two unique parameters, B and A. **Parameter** B defines the **Standard Pavement Balance Curve (SPBC)** of the data, and **parameter** A describes the **state of balance** of the same data. The DCP data are classified into one of **nine possible pavement strength - balance categories**.
With this data the pavement can be classified as either a **shallow, deep** or **inverted pavement** structure, which can be either **well - balanced, averagely balanced or poorly balanced**.

Furthermore, the pavement can be divided into different layers, based upon the in situ measured strength, by using the variation in the deviation (parameter A) of the Standard Pavement Balance Curve (SPBC), with depth. These newly defined layer interfaces correspond to discontinuities within the in situ pavement structure and are **essential** in defining the pavement structure with regard to the **analysis and understanding** of **basic pavement behaviour**.

Two **DCP computer programs** have been developed to **analyse** and **classify** the DCP data in terms of the concept of **pavement balance**. Based on the relative DCP strength of the individual pavement layers, the failure mechanisms such as **permanent deformation** and **fatigue cracking** of pavements may also be explained.

It is my opinion that this method of classification, will be of great assistance in particular to inexperienced users of the DCP instrument as a pavement design and evaluation tool. It is further envisage that this universal method of classifying DCP data and hence flexible pavements, will contribute largely towards a sound **basis of comparison** between different pavements and different failure mechanisms of pavements in general.

The implementation of the pavement strength - balance classification system will improve current methods for designing new pavements and rehabilitating existing pavements, particularly in the developing countries in southern Africa where the existing road network needs to be extended or rehabilitated.

As mentioned earlier, this system was used to analyse all the DCP results in this study and it was found very helpful in the definition of the in situ pavements structure as well as changes in the pavement owing to traffic loading and certain moisture conditions.

Finally, it is recommended to apply this classification system (and the associated concepts) to other flexible pavement types, as well as the supporting structure of rigid pavements in order to verify and possibly adjust some the concepts indicated in this chapter for wider application.

3.8 REFERENCES

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