PAVEMENT STRENGTH BALANCE AND ITS PRACTICAL IMPLICATIONS

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Abstract
The fact that pavements are composed with the strongest layer uppermost in the structure followed by layers of material with diminishing structural contribution is not per chance. Naturally evolved road pavements demonstrate the same in situ strength arrangement. The concept of strength-balance in terms of pavement composition is not new but what does it really mean and, moreover, what are the benefits of having a strength-balanced pavement and how may the principle be applied in practice. One can design and compose pavements to be "strength-balanced". This paper relates this concept to the original observations in roads and the Heavy Vehicle Simulator test programme and practice by giving some design and rehabilitation pointers and implications. The strength-balance concept will also be utilized to motivate rehabilitation design based on the existing pavement strength profile.

1. INTRODUCTION

The fact that pavements are composed with the strongest layer uppermost, followed by layers or strata of material making a diminishing structural contribution to the overall pavement strength is not accidental. Naturally evolved road pavements, for example roads that developed from vehicles travelling the same farm to market route over a period of the years, also demonstrate a tendency towards that very same *in situ* strength profile. Over many years a number of engineers have contributed towards a better understanding of the principles backing this observation and hence road pavement behaviour and composition (i.e. Yoder and Witczak, 1975).

Many of these basic hypotheses and concepts were also confirmed through application of the Dynamic Cone Penetrometer (DCP) to road pavement assessment (Kleyn, 1975; Kleyn, 1984). While the ability to gain an insight into the immediate *in situ* condition of an existing pavement much alleviated "blind trust" speculation regarding the strength profile of a pavement, the value of the DCP lay therein that it supported the concept of compaction under traffic and also that of re-moulding by traffic towards the attainment of a strength profile that exhibits a smooth decrease in strength with increasing depth. Moreover, the application of the Heavy Vehicle Simulator (HVS) (in combination with the DCP) in the investigation of the behaviour of variously composed pavement structures took this a step further in demonstrating the existence of this phenomenon.

The result was the formulation of the Traffic Moulding and the Strength-Balance concepts and the development of the Standard Strength-Balance Curves for pavements - defining what appears to be the ideal strength profile associated with optimum performance. This paper discusses these principles, the improvement in understanding of pavement composition and behaviour it affords and its application in practice with an aim towards optimal utilization of the resources of the planet. It is deemed important that new pavement engineers take cognisance of these concepts to improve their understanding of pavement behaviour and to support the design and construction of more economical and balanced pavement designs.

2. PAVEMENT STRENGTH-BALANCE PHILOSOPHY

2.1 Burrow investigation

Observation of the phenomena that led to the recognition and development of the Traffic Moulding concept and Strength-Balance Curves started in 1973 during the "Burrow Investigation" regarding the soundness of the pavement design philosophy of the Roads Department of the former Transvaal Provincial Administration (TPA) comprising the combined areas of the present Limpopo, Mpumalanga, Gauteng and part of North West provinces (Burrow, 1975). During this investigation, between 1 500 and 2 000 test pits were excavated for material and pavement design appraisal purposes in a representative sample of the provincial road network which had been in service for at least 20 years at the time. These roads consisted mostly of stabilized and natural gravel pavement combinations with a thin chip and spray surfacing. DCP soundings and excavations were done down to 800 mm at each of these test pits and the observations, field readings and laboratory tests results recorded (Kleyn, 1975; Kleyn, 1984; Kleyn and Steyn, 2010).

Apart from the expected observation that the pavements were not all of similar strength and composition, it was also observed that the DCP derived strength profiles tended to exhibit a similar strength-profile, both on older pavements that were performing well as well as on pavements that had deformed and could be classified as having failed functionally (deformed badly). The strength profiles, for the most part, showed a relatively smooth transition of strength with depth although they were constructed in the traditional layered fashion – however, not all at the same rate of change and sometimes also interrupted by a relatively stronger (usually) stabilized gravel stratum.

2.2 HVS investigations

This phenomenon was further investigated during the HVS assessment of the local pavements under varying loads. Monitoring of the strength profile of pavements under HVS trafficking brought to light that the strength profiles of pavements were subject to change depending on wheel load and natural or simulated climatic conditions. The bearing capacity and load sensitivity of a pavement could be amended either negatively of positively by the traffic load – explaining why some pavements after construction (sometimes later in their lives), would exhibit noticeable deformation under traffic only to seemingly inexplicably stop deforming and perform well over the remainder of their expected life cycle.

This investigation led to the formulation of the Traffic Moulding principle, namely that the traffic load tends to deform and iron out any abrupt strength differentiations (steps) within a pavement towards a smoother strength-depth profile to the degree that the load exceeds the immediate bearing capacity of the pavement materials. Monitoring by DCP showed that this phenomenon usually started at the location within the pavement where the material was being overstressed, such as at cemented/un-cemented layer intersections or where relatively sharp differences in material stiffness/quality occurred (Figure 1) (Kleyn, 1984; Kleyn and Steyn, 2010).

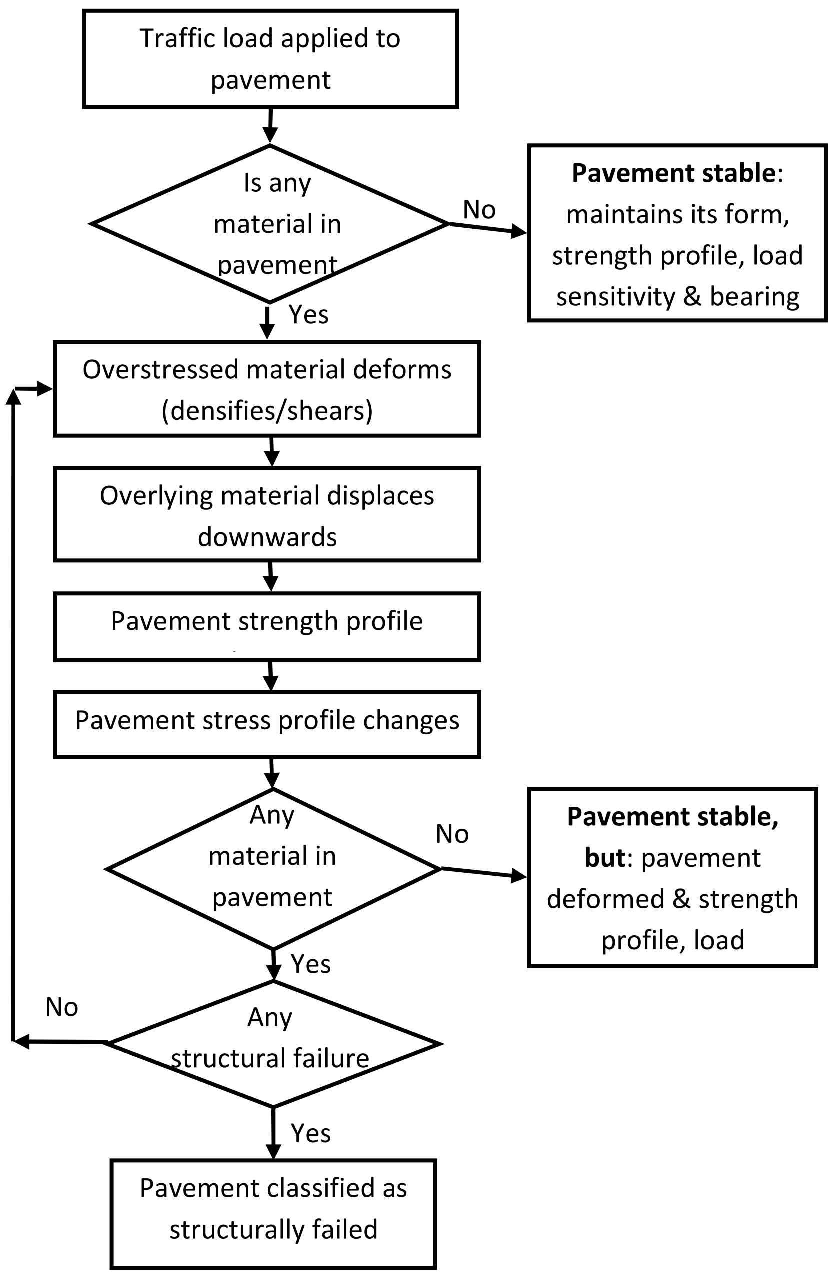


Figure 1: Schematic illustration of the phenomenon of Traffic Moulding

Note that overloading of a pavement is a relative term. It is well-known that traffic loads deform pavements to a varying degree. This deformation has two components, namely elastic and plastic deformation (Wolff et al, 1992). In pavement engineering the intention is to limit the plastic deformation such that its accumulation will not exceed the functional limiting specification (rutting) nor the structural limiting specification within the structural design period of the pavement. Overloading is the term indicating a load that deforms the pavement to a degree that enhances failure mechanisms such that specified pavement failure levels are reached short of the structural design period. Overload criteria and failure mechanisms differ significantly for different pavement compositions.

It was found that the strength profiles could be represented in a manner that would distinguish between different strength profiles, irrespective of pavement strength or bearing capacity. This was achieved by plotting the *in situ* zone/layer strength as a percentage of the total pavement strength (expressed in terms of DCP Structure Number, DSN) against the pavement depth.

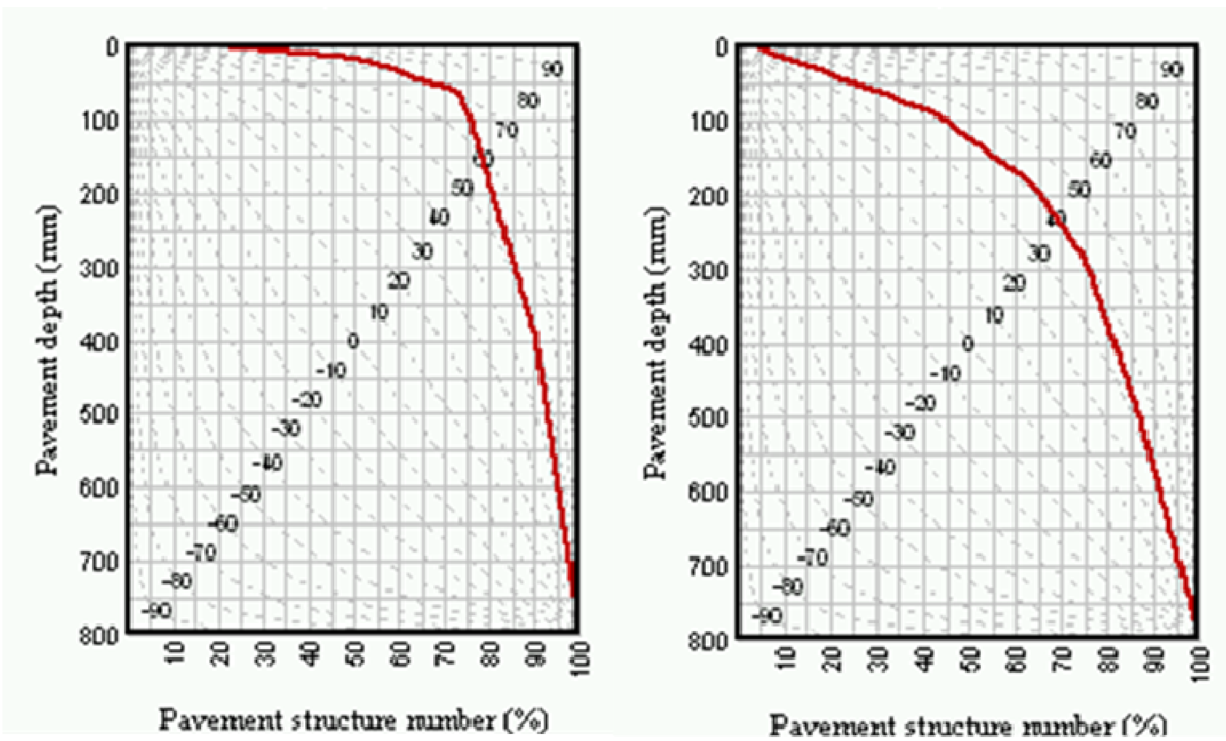


Figure 2: SSBC diagrams showing shallow and deeper pavement strength profile.

When analysed it was found that a series of curves could be plotted to represent the best fit curves of these *in situ* strength profiles. This led to the compilation of the Standard Strength-Balance Curves (SSBC) shown in Figure 2, considered indicative of the ideal strength transition of a Strength-Balanced Pavement (Kleyn, 1975; Kleyn, 1984; De Beer, 1991; Kleyn and Steyn 2010). Although the SSBCs were originally developed for a pavement depth of 800 mm the general form of the equation can be expressed as indicated in Equations 1 and 2 - proving that they actually are specific sections of the same “master” Strength-Balance Curve (Kleyn et al, 1989). In order to identify the various segments of the SSBCs more readily, a parameter called the Balance Number (BN) was introduced. BN is that percentage of the pavement DCP Structure

Number over a depth of 800 mm (DSN_{800}) achieved at a pavement depth of 100 mm (Equations 3 and 4). With these equations any pavement can be designed or analyzed for strength-balance.

Percentage strength S = 7BN*D **/** [(100 – BN) – D*(1 – 0.08BN)] (Eq.1)
Percentage depth D = S*(100 – BN) **/** [7BN + S*(1 – 0.08BN)] (Eq.2)
Balance Number BN = (DSN_{100}/DSN_{800})*100 (Eq.3)
or in general form as:
Balance Number BN = S*(100 – D) **/** [(7D + S*(1 – 0,08D)] (Eq.4)

Note that the higher the BN, the more the upper portion of the pavement contribute to the overall structural value of the pavement – and vice versa. Thus, a pavement within which the structural value decreases relatively rapidly with increasing depth may be considered to be a pavement tending towards being shallow, while a relatively deep pavement is a pavement within which the structural value of the layers decreases relatively slowly with increasing depth. Further refinements on the equations resulted in the computerized version of the analysis procedure which is currently widely used in various forms (de Beer *et al*, 1988).

2.3 Practical implications of traffic moulding and strength-balance

Various practical implications emerge from the abovementioned observations regarding Traffic Moulding and/or Strength-Balance, such as:

- **Traffic Moulding:** Despite the constructed strength profile of a pavement having a specific, and usually layered, appearance, the traffic carried by the pavement will always tend to smooth out the abrupt strength profile changes (in accordance with the Strength-Balance concept) if the bearing capacity of the material at any level is exceeded by a load. This means that the process of Traffic Moulding can be initiated by a single overload, one or more heavy loads or the entire traffic spectrum, setting in motion a sequence of events whereby the pavement may become increasingly sensitive to an increasing percentage of the traffic spectrum, manifesting the signs of distress/failure at an increasing rate. Hence, a normally safe traffic spectrum can momentarily overload a pavement, for instance, because of the effect of a climate change – like the onset of the rainy season. Thus, the load sensitivity and bearing capacity of a pavement is a continually varying commodity – it is "alive".

  Overloading may also mould the overstressed layer towards an increased bearing capacity as result of an increase in density, becoming less sensitive to the loading conditions – and the traffic moulding eventually stops although the functional surface defect (deformation) of the pavement remains. Also note that deterioration of the functional condition of a pavement will result in an increase in the effective load of the traffic spectrum as result of the impact of the wheels – which may continue the Traffic Moulding action to a point where the pavement is much stronger than necessary for the same traffic spectrum on a pavement with a higher functional condition, before the traffic moulding stops.

- **Effective depth:** The effective depth of a pavement is not necessarily the sum of the layers applied during construction and also not necessarily a constant. The effective pavement depth could be defined as that depth below the surface at which the traffic load has been dissipated by the pavement structure to a negligible value. This value may be that which can safely be handled by material with a CBR of 3 per cent (as is generally accepted in South Africa) but it can also be a value which applies to a specific *in situ* condition and project. Therefore, the effective pavement depth not only varies continuously in synchronization with the traffic load but it is also governed by the type of Strength-Balance of the pavement. Furthermore, should the pavement structure (still) be in the process of being molded by the traffic towards a new Strength-Balance (either increasing in bearing capacity or failing) its effective depth will also be in transit.

- **Barriers to Traffic Moulding:** A pavement can be purposely or accidentally built with an artificial barrier to traffic moulding by having a relatively stiff/rigid layer near the top causing a distinct disruption in its strength profile and an artificially shallow effective depth. This might perform well for years since the barrier layer is strong enough to absorb most of the load. However, a specific load may overstress and shatter this layer (especially if it is cemented) after which the pavement "inexplicably" deforms and fails rapidly, mostly because the failed barrier layer normally has not got the inherent ability to be moulded to a higher strength state. Many of the older pavements were inadvertently designed and built in this way by adding a cemented base/subbase to an otherwise reasonably well balanced but relatively low bearing capacity pavement in an attempt to increase its bearing capacity. This often made for a overload sensitive pavement and one of the main causes of the "pumping and equivalent granular state" condition. This phenomenon was realized during the HVS testing programme by the local road authorities and research institutes who amended their recommended pavement design philosophy by extending the subbase zone, thus increasing the pavement depth for heavier pavements and making it less overload sensitive.

- **Tyre/pavement interface:** It was noticed in practice and under HVS testing that despite a pavement having sufficient overall bearing capacity regarding axle load demands and even being reasonably well balanced, the tyre contact stresses could cause shear failure within the upper 50 mm of a pavement. This means that one should not only design for the overall bearing capacity of a pavement but also ensure that the tyre/pavement interface (surfacing and top part of the base) can withstand the applied tyre pavement contact stresses (De Beer et al, 2004).

- **Rigid versus flexible pavements:** It is interesting to note that the two basic pavement classifications (rigid and flexible) may also be defined in terms of the strength-balance concept. A rigid pavement (such as a concrete slab supported by modified and/or natural gravel) normally conforms to the definition of a very shallow pavement (depending on the thickness of the concrete relative to the rest of the pavement). The top part of the pavement (base/concrete) essentially carries the load with relatively little assistance from the lower zones of material (Yoder and Witczak, 1975). Hence, the shallower a pavement is the more it behaves like a rigid pavement – and conversely, the deeper a pavement becomes the more it behaves like a traditional, more overload tolerant, flexible pavement. It was also noticed that shallow pavements tend to fail upwards through the stiff/cemented zone/layer (traditional layer fatigue behaviour) while deep pavements tend to fail from the top downwards.

- **South African "upside down" pavement composition:** The strength-balance concept assists in the understanding of the behaviour of the South African "upside down" pavement composition. These pavement compositions was born during the early days of the HVS program, when it was noticed that local Crushed Stone (G1) bases could be constructed to a much higher specification than the normal crusher run material and that such pavements performed much better when supported by a sound (cemented) sub-base zone and high quality sub-structure. This constitutes a relatively deep pavement composition in which the neutral plane lies well below the unbounded base layer. At first glance this cross section seems to suggest a pavement composition which has a relatively low strength base supported by an unduly strong sub-structure (upside down to normal convention). However, the high strength of the Crushed Stone (G1) layer (high quality aggregate particles compacted to a state of such intimate contact (density) as to resist any load up to the point of aggregate fracture) has to be appreciated in this structure.

3. APPLICATION OF THE STRENGTH-BALANCE CONCEPT

Application of the accumulated knowledge regarding road construction materials and the behaviour of different pavement compositions under varying climatic and traffic conditions is the key to effective pavement design – be it from basic principles or the use of computerized models. The concepts of Traffic Moulding and Pavement Strength-Balance has only opened the door a little wider towards optimal utilization of that knowledge and our natural resources – its value depends on how well it is integrated with the existing principles and procedures.

It should be clear that the behaviour and performance of a pavement can be enhanced by composing and constructing it such that its strength profile approaches that of the Strength-Balance Curves as best as is practically possible. This strength transition may be depicted by the Standard Strength-Balance Curves and formula developed. The principle may be applied to initial pavement design as well as to rehabilitation of existing pavements.

3.1 Initial pavement design

Since there are numerous pavement design methods and procedures internationally, the approach given below is aimed at providing general direction that will allow the designer the freedom to use a locally favoured method to determine specific aspects according to their local preference. This means that a "standard" design catalogue can be applied for the situations most frequently encountered for future reference or standardization purposes. These steps can be outlined as follows:

i. **Determine the traffic spectrum to be catered for:** This entails determining the composition of the traffic with respect to types and numbers of vehicles to be carried by the pavement.
ii. **Decide on a structural design period for the pavement:** This is the period during which it is predicted that no structural maintenance will be required, linked to a specified design

reliability. This period may be fixed by policy or guided by performance data from the pavement management system.

iii. **Decide on target pavement strength-balance:** This entails finding out how much vertical space is available for the pavement. In other words, is the depth and supportive value of the *in situ* material such that it can be incorporated into the pavement design and allow for a relatively deep and less overload sensitive pavement or is the in situ material depth and/or quality such as to enforce a relatively shallow and more overload sensitive pavement.

iv. **Determine the bearing capacity of the pavement:** Using the equivalency factor appropriate to the strength-balance selected for the pavement to be designed, convert the traffic spectrum to Million Equivalent Standard Axle (MESA) repetitions over the structural design period of the pavement. Although no definite rule is provided for the value of exponent "n" in the equivalency formula $F = (P/SA)^n$, it is known from HVS test results that this figure lies between 1.5 and 6 for local pavements. This figure is governed by the strength-balance configuration such that average local pavement corresponding to a Balance Number of around 40 per cent seems to have an "n" value between 3 and 4, while the deeper pavements can have an "n" value as low as 1.5 and shallower pavements an "n" value of around 6. This might seem like a small range but it has a very noticeable effect on the equivalent traffic load experienced by the pavement. The pavement has to be designed to have at least this bearing capacity in real terms over the chosen structural design period.

v. **Determine the strength contribution for the various zones in the pavement:** The required strength at various depths within the pavement (say, base, sub-base and selected layer zones) can be determined from the selected target SSBC for the pavement as illustrated in Figure 2. The example shows the calculation result figures for two different compositions, the solid line layer delineations for a 100 mm base with 150 mm subbase and two selected layers on a 250 mm subgrade, while the dashed lines are for a 150 mm base, subbase and two selected layers on a 200 mm subgrade. Hence, the effect of varying the zone/layer thicknesses may also be evaluated in this way. Obviously the pavement will be constructed in a step-wise fashion because of practical considerations and constraints and thus its strength profile will only approximate the target strength-balance. Note that the final strength parameters may be in any convenient format.

vi. **Assess the *in situ* and/or borrow-pit material for suitability:** Evaluate the laboratory and/or in situ strength measurements against the strength requirements for the different zones/layers, as determined in the previous step, for suitability and treatment type.

vii. **Decide on the optimum life cycle strategy for pavement:** The life cycle strategy can have a profound influence on the final composition of the pavement since it incorporates the predicted maintenance and rehabilitation programme for that pavement based on its anticipated behaviour under prevailing conditions. It normally includes the funding needs programme for the specific pavement. It is considered that the design process is the first step in the life cycle of a pavement and lays the foundation for the maintainability and salvage value of the pavement.

viii. **Specify use of material and pavement profile for construction purposes:** Compose the pavement profile and specification such that it approaches the target strength-balance profile as close as practically possible while keeping local practice and cost-efficiency in mind. Incorporate as much of the in situ material into the pavement profile, either as is, reworked or imported. Avoid using any material within the effective pavement composition close to its strength/density limit or one with a very shallow strength/density gradient since this can encourage excessive traffic moulding and decreased structural failure.

Note that one may also purposely design a pavement such that it will either initially undergo controlled Traffic Moulding in order to save on initial construction energy, or, to gain strength in step with its traffic growth. Functional rehabilitation may then be applied as necessary.

3.2 Rehabilitation or upgrading pavement design

Determining the functional and/or structural anomaly of a pavement that has been classified as failed represents only the current manifestation of a time-line process that has been on-going over a period. One could concentrate only on fixing the current anomaly but should address the cause of the current state of affairs in order to be able to fully handle the situation and avoid future recurrence of the failure mechanism.

Firstly, one needs to know the postulated ideal scene for the pavement in order to have a standard against which the existing scene can be evaluated and used to guide the rehabilitation/upgrading design/composition. This might be as basic as knowing from experience what the ideal scene for the type of road is or stating that the road should carry a certain amount of traffic for a certain length of time without becoming unserviceable. It might also state the ideal functional limitations and structural qualities to support this functional ideal and, thus, minimum properties of the pavement components. This provides the specified or locally accepted distress or failure criteria against which to evaluate the *in situ* condition and trace the origin/cause of the present condition.

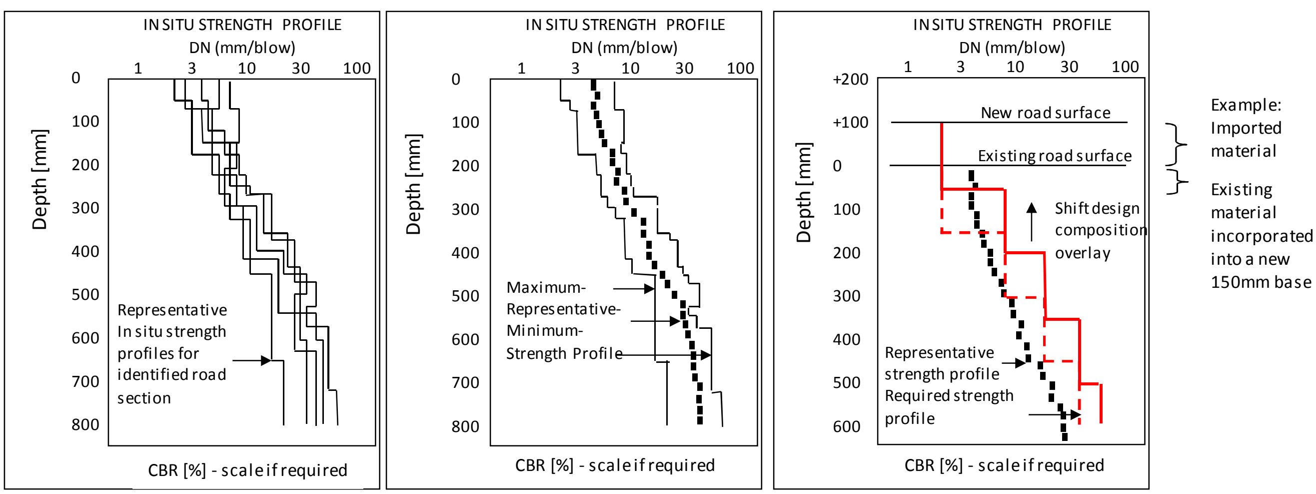
Next, the *in situ* conditions need to be determined to find out where and by how much it deviates from the ideal scene. The general condition of the pavement, in other words, is the pavement still “failing” or has it been moulded into a higher bearing capacity and more stable composition that can now handle the traffic better or even successfully despite its functional condition – identify the position on its Traffic Moulding cycle.

The traffic loading that the pavement has experienced is not merely calculated from the present structural condition followed by a deduction of the required rehabilitate action – it is usually very misleading. First, the current visual condition of the pavement and the area in which it is situated (geological, physical, environmental condition that could impact on the behaviour and performance of the pavement) should be identified. A proper structural assessment usually also assists in clarifying the present visual and internal condition of the pavement. If done timely and correctly, it might be found that the existing strength profile of the *in situ* material (like an existing gravel road or surfaced pavement) may be adequate or need only one additional layer of imported material to handle the anticipated traffic load.

When rehabilitating or upgrading an existing pavement the structural condition of the pavement needs to be determined. This knowledge may also assist in determining the sequence of events that led to the present pavement condition. This evaluation is performed against the knowledge of the ideal scene for pavements in general and the guidance of the rehabilitation/upgrade pavement composition (design) in particular. Thus the representative *in situ* strength profile of the existing pavement is required (e.g. from DCP, FWD or other measurements) and needs to be compared to the ideal strength profile.

It must be appreciated that traffic moulding of the pavement is either continually taking place towards ultimate structural failure or increased bearing capacity. In the case of the bearing capacity improving, deformation should stop when equilibrium between the traffic load and the bearing capacity of the pavement is reached. The pavement is now stable under the prevailing traffic and other conditions. Sometimes the required bearing capacity is reached before functional failure, such that only cosmetic rehabilitation (resurfacing) is necessary to restore the serviceability of the road.

For example, to obtain the representative *in situ* strength profile a representative number of strength profile measurements per pavement section could be done and plotted onto the same strength profile form (Figure 3a). This is used to enable identification of the best and worst *in situ* condition boundary profile, as well as the representative strength profile for that particular section of road (Figure 3b). In this process "outliers" or a section of pavement for which the strength profile differs too much from the other strength profiles in that group may be identified, indicating that it may belong to an adjacent section of pavement or needs to be treated separately.



3a 3b 3c

Figures 3a, 3b and 3c: Diagrammatic example of utilizing *in situ* pavement structure

The representative *in situ* strength profile does not necessarily constitute the average of the minimum and maximum *in situ* strength profile but may be biased towards either one of the boundaries depending of the risk factor adopted for the particular design strength profile. For deeper zones in the pavement the risk factor normally diminishes, and so it might be that the representative *in situ* strength profile may start out more biased towards the minimum strength profile while the representative *in situ* strength profile may gradually shift towards the average, or even maximum *in situ* strength profile with depth. This, of course, is very much governed by the design strength profile, drainage and sub-soil conditions.

Note that the *in situ* pavement material is normally compacted by the traffic to a higher density than achievable by the standard laboratory energy (i.e. beyond 100 per cent Mod AASHTO) and should register a higher strength/bearing capacity than possible with the normal laboratory apparatus. If this is not the case, unfavourable *in situ* pavement conditions such as excess moisture and/or borderline/substandard material may be suspected.

The representative *in situ* strength profile of the existing pavement (which is to be evaluated against the required or design strength profile) is dependent on the ratio between the survey moisture regime and the anticipated operational moisture regime of the pavement – the moisture regime ratio. It is preferable to do the strength profile survey when the moisture regime of the existing pavement is similar to the anticipated "design" moisture regime. At the time of the *in situ* strength profile survey some representative samples of the *in situ* material should be taken for laboratory appraisal of the basic material properties of the different layers/zones of material and possible application during the design and composition of the new/upgraded pavement.

To determine the most suitable rehabilitation or upgrading composition means that the required or design strength profile must be evaluated against the representative *in situ* strength profile for the particular section of pavement in order to ascertain what part of the *in situ* pavement can be incorporated into the design strength profile. The *in situ* strength profile should not summarily be destroyed in the rehabilitation/upgrading process by re-working the material but should, if at all possible, be incorporated undisturbed into the new pavement design.

The design strength profile may be obtained from the pavement design catalogue of the particular road authority or a specific design may be calculated or adapted to optimize the representative *in situ* strength profile. Whichever route is followed to obtain the design strength profile, it is suggested that a Strength-Balanced pavement composition should be aimed for because of its superior utilization of materials and performance.

Basically, comparison between the required and *in* situ pavement strength balance may be obtained by drawing the required design strength profile separately on a transparency, to the same scale as the strength profile diagram for the *in situ* conditions (Figure 3b) and using it as an overlay on the *in situ* strength profiles (Figure 3c). The overlay profile may be moved relative to the *in situ* strength profile to obtain an indication of how the *in situ* strength profile may best be utilized to approach the design pavement composition (Figure 4). This process may of course be computerized.

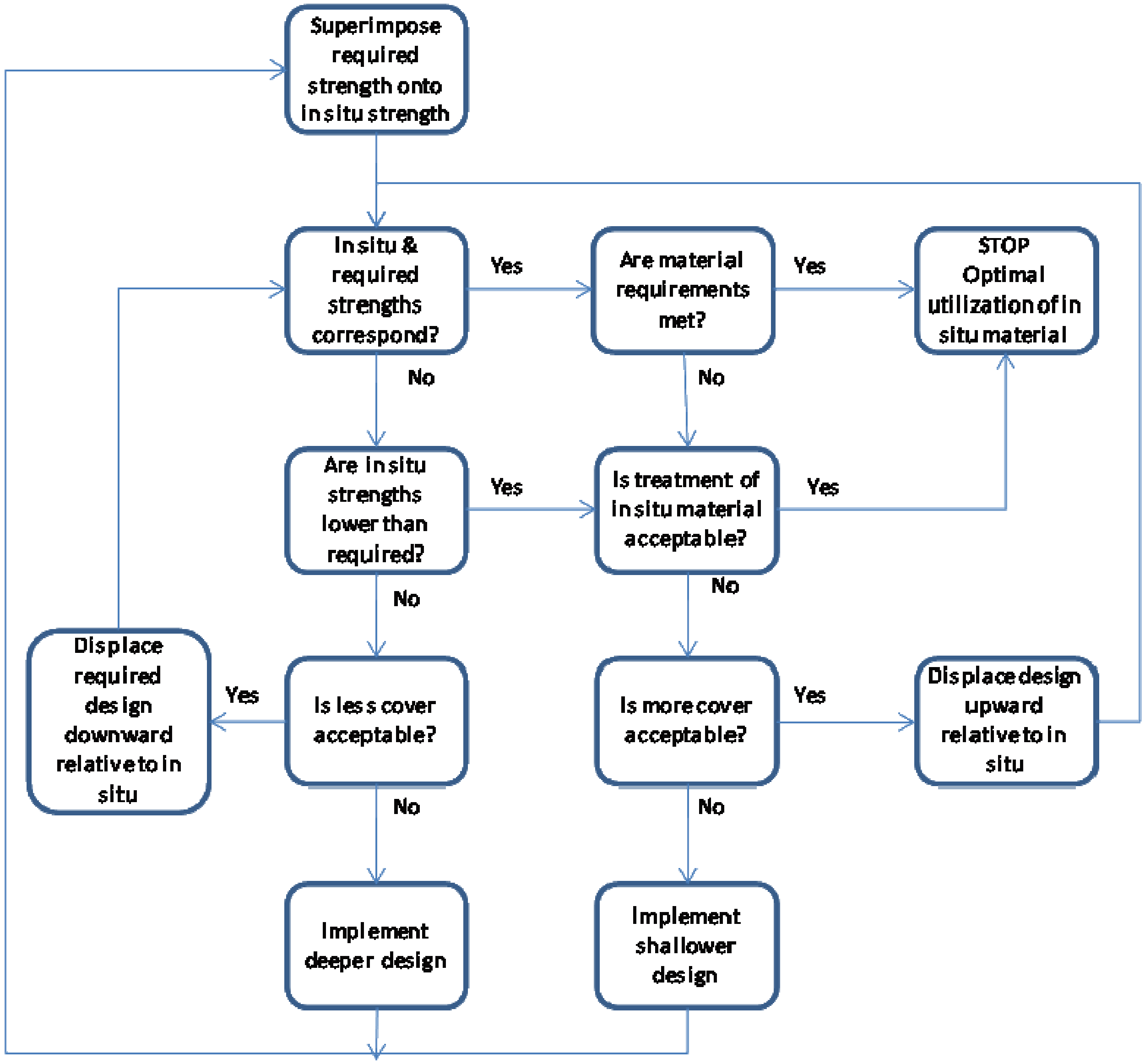


Figure 4: Optimizing the utilization of in situ pavement material

While the strength-depth ratio of the design strength profile may be adjusted to obtain a shallower or deeper pavement composition in order to utilize the *in situ* strength profile optimally, one may be cautioned against over-doing this in an effort to get absolute correlation, especially with the deeper zones in the pavement which are not so sensitive to strength-balance as the upper layers. As a general rule of thumb, the higher the *in situ* strength versus the design strength ratio is, the more reason exists to utilize the *in situ* pavement as-is, without re-working. In this way it may be found that the existing pavement only needs one imported base layer or the stabilization of the existing base layer to serve as a sub-base for an imported base course.

4. ANTICIPATED FUTURE DEVELOPMENTS

The ability to measure the *in situ* strength profile of a pavement afforded by the advent of the DCP on the scene of pavement condition and behaviour monitoring was very timely especially when viewed in conjunction with the HVS programme. This cooperation not only gave an insight into the immediate strength profile of pavements under normal operational conditions but also in the change of strength profiles and behaviour of such pavement structures under HVS trafficking. Admittedly the DCP cannot penetrate the higher order pavement materials but it set the ball rolling regarding monitoring of pavement structures under traffic. This resulted in the accumulation of understanding regarding pavement behaviour which would not have been possible without the HVS or the DCP. The following is seen as required further developments in this area:

- Further investigation to unravel the rules that govern the development of the different Strength-Balance types;
- The influence that the Strength-Balance of a pavement has on its load sensitivity and how this may change and affect the behaviour and performance of a pavement over its life cycle;
- Understanding and handling the effect of tyre contact stress and the interface zone between it and the axle load zone on the traffic moulding and strength-balance process;
- Assessing the behaviour and bearing capacity of an existing pavement that contains an abrupt Strength-Balance interruption, such as caused by a relatively stiffer layer (as may be expected when rehabilitating a pavement using Deep In Situ Recycling techniques);
- Steering an existing pavement with judicious rehabilitation towards improved Strength-Balance and performance, and
- The process of ensuring that a well balanced pavement remains balanced during the continuing process of traffic moulding due to traffic loading and both short- and long-term environmental changes.

5. CONCLUSIONS

The following conclusions are drawn based on the information contained in this paper:

- The phenomenon of traffic moulding towards more optimal strength-balance affects the bearing capacity of a pavement directly and should be appreciated and understood in order to enable optimal pavement design, construction, maintenance and rehabilitation through utilization of available resources and scarce materials, and
- Traffic moulding is affected by both traffic loading and environmental changes, causing the effective bearing capacity of a pavement to continuously change.

6. RECOMMENDATION

It is recommended that the information contained in the paper and related references should be used to understand the process of dynamic pavement evolution due to traffic moulding and the effects of construction, maintenance and rehabilitation actions on the ultimate performance and behaviour of the pavement.

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KEY WORDS

Pavement design, Traffic Moulding, Strength-Balance, DCP