

TRH

NOMENCLATURE AND METHODS FOR DESCRIBING THE CONDITION OF ASPHALT PAVEMENTS

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TECHNICAL RECOMMENDATIONS FOR HIGHWAYS

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**NOMENCLATURE AND
METHODS FOR DESCRIBING
THE CONDITION OF
ASPHALT PAVEMENTS**

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PREFACE

TECHNICAL RECOMMENDATIONS FOR HIGHWAYS (TRH) are written for the practising engineer and describe current, recommended practice in selected aspects of highway engineering. They are based on South African experience and the results of research and have the full support of the committee of State Road Authorities (CSRA).

This document was produced by a subcommittee of the Highway Materials Committee and, to confirm its validity in practice, was circulated in draft form for a trial period before being submitted to the CSRA for final approval, which it has now obtained.

SYNOPSIS

A set of terms for describing the condition of asphalt pavements is proposed. These are divided into two classes. The first covers functional aspects i.e. those that affect the comfort, safety and convenience of the road user. The second covers structural aspects, i.e. those that determine the resistance of the pavement to the effects of traffic and the environment. Because distress plays a major role in the assessment of pavements, methods for describing it are presented in considerable detail. A few examples of how these terms are used in practice are given. Finally, the terms defined are summarized in a Glossary.

SINOPSIS

'n Stel terme vir die beskrywing van die toestand van asfaltplaveisels word voorgestel. Dit word in twee klasse ingedeel. Die eerste dek die funksionele aspekte, dit wil sê dié wat die gemak, veiligheid en gerief van die padgebruiker beïnvloed. Die tweede dek strukturele aspekte, dit wil sê dié wat die bestandheid van die plaveisel teen die effekte van verkeer en die omgewing bepaal. Omdat verswakking 'n hoofrol speel in die beoordeling van plaveisels, word die metodes vir die beskrywing daarvan in taamlike besonderhede aangebied. 'n Paar voorbeelde van hoe dat hierdie terme in die praktyk toegepas word, word ingesluit. Ten slotte word al die terme wat gedefinieer is, in 'n glossarium opgeneem.

KEYWORDS

Nomenclature, distress attributes, asphalt pavements, distress mechanism

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1 INTRODUCTION

The need for describing the condition of pavements occurs frequently in road engineering. Specific examples of this are:

- (a) reporting information about pavements within the hierarchy of the road authority;
- (b) recording the condition in pavement management systems;
- (c) communication between engineers, either with a view to transmitting useful observations or to soliciting advice;
- (d) expressing standards for maintenance* requirements; and
- (e) expressing the outcome of experiments and developing meaningful relationships that may be used in practice.

Over the past years a variety of terms has been brought into use for these purposes. However, many of them have not been defined explicitly or used uniformly. Hence much reporting has been unsatisfactorily vague or ambiguous. A set of terms for describing the condition of pavements is presented in this document as a standard nomenclature in order to facilitate communication within and between road organizations.

There are two points of view from which the condition of a pavement should be considered. These are those of the road user and the road engineer. The road user regards the road as a service provided for transportation and he appraises the condition of the pavement in terms of those characteristics that affect him, notably his comfort, safety and convenience. The engineer, on the other hand, recognizes these *functional requirements*, but also views the pavement as a load-bearing structure that must be timeously maintained if it is to remain serviceable. Descriptions of the pavement are generally provided with an *evaluation* of the condition in mind. This may then be a *functional evaluation* (i.e. one from the point of view of the road user) or a *structural evaluation*. These are respectively based on *functional descriptions* and *structural descriptions* of the condition of the pavement.

Although no attempt is made here to suggest how such evaluations are to be performed, the various terms required for describing the condition are presented within the context of these two types of evaluation. Section 2 defines concepts and methods for providing functional descriptions of the condition of the pavement, and Section 3 defines the various properties that are required for a structural evaluation of the pavement. The use of critical values of the condition of the pavement is discussed in Section 4.

*In this document "maintenance" is used as a generic term embracing routine maintenance, special maintenance and rehabilitation.

The deterioration of the pavement that is visible at the surface is called pavement *distress*. Because distress is easily observed, recording it plays a central role in assessing the condition of the pavement. In view of the importance of distress, the terms used for describing it are given in detail in Appendix A.

The nature and detail of the required descriptions will depend on the specific purpose of the assessment. Since recommendations for the evaluation of the condition of the pavement are not within the scope of this document, it is assumed that the engineer will state what properties are of interest for his particular purpose. The terms defined here enable him to specify the nature of the desired description and to interpret the results unambiguously. Appendix B gives examples of typical rating requirements, which may be used as a guide.

Most of the terms are introduced and defined informally in the text. These are finally summarized in the form of a glossary.

2 FUNCTIONAL DESCRIPTION OF PAVEMENT CONDITION

The functional requirements of a pavement are the required standards of those properties of the pavement that affect the service it provides to the road user. They are predominantly those that govern his comfort, safety and speed of travel*. The extent to which a pavement meets the requirements of the user is defined as the *serviceability* of the pavement. The minimum level of serviceabil-

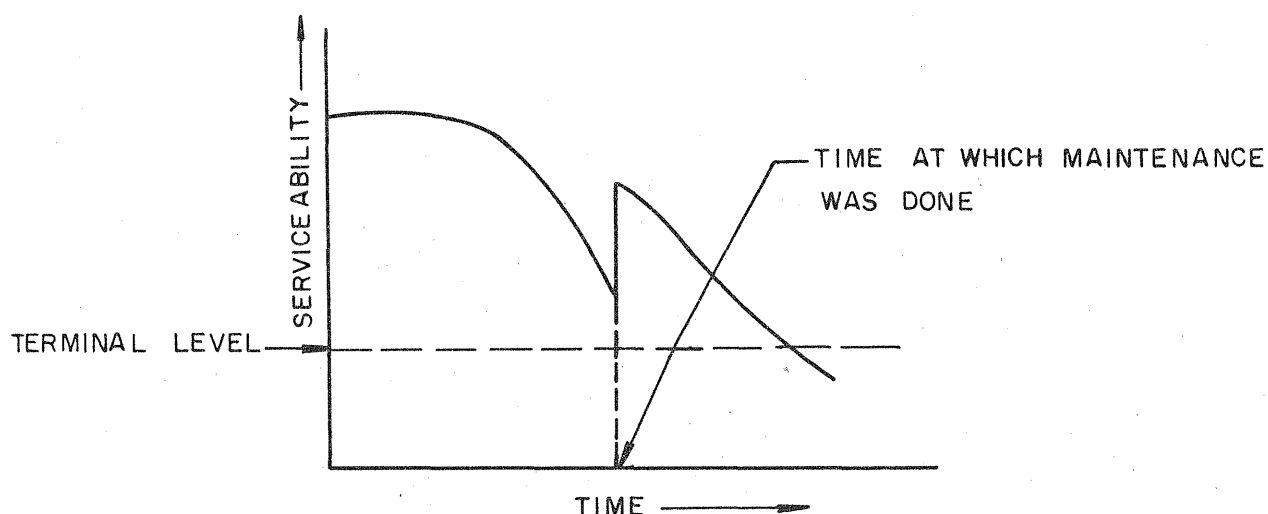


FIGURE 1

The performance of a hypothetical road

*Note that the pavement is only one part of the road. The functional requirements of the road as a whole consequently incorporate those of the pavement.

ity that may be allowed for a particular pavement (or class of pavement) is termed its *terminal level of serviceability*. During the life of a road the serviceability of the pavement will vary. This variation over a period of time is called the *performance* of the pavement, i.e. performance is the serviceability as a function of time. Figure 1 gives an example of the performance of a hypothetical pavement in order to illustrate these concepts.

The functional requirements, comfort, safety and speed, are not easy to assess directly. They are in fact not unique; the various values are interrelated (for example safety depends partly on speed) and the exact nature of the relationships is not well known. Furthermore, for pavement management purposes it is insuf-

TABLE I
Assessment of pavement serviceability

FEATURES	FACTORS CONTRIBUTING TO SERVICEABILITY	METHOD OF ASSESSMENT
1 Riding quality	(a) Longitudinal surface roughness (deformation) (b) Rutting in wheelpaths (deformation) (c) Potholes (ravelling) (d) Uneven patching	(i) Subjective assessment in a vehicle (ii) Measurement of riding quality using PCA roadmeter*, LDI, BPR roughometer* Straightedge measurements Regular inspection Inspection (also included in (i) and (ii) above)
2 Skid resistance	(a) Surface texture depth (b) Harshness of surface (c) Water film thickness	SCRIM, NITRR brake-force trailer, pendulum apparatus** See (3) below
3 Surface drainage	(a) Transverse and longitudinal grades (b) Efficiency of drainage system (c) Deformation of surface profile, particularly rutting in the wheel-paths	Levelling, inspection during rain Assessment of condition of shoulders and drainage paths, inspection during rain Inspection during and after rain, straightedge measurements

*Instruments must be calibrated from present results obtained subjectively by a panel of raters (see Section 2.1).

**See Section 2.2.

ficient merely to know a value for say safety: the way in which the road is unsafe is also important. For these reasons various *functional features* of the pavement are defined. These are features that can be measured and for which standards can be set in such a way that they collectively ensure that suitable levels of comfort, safety and speed are achieved. For surfaced roads these are the riding quality, skid resistance and surface drainage of the pavements and to a lesser extent environmental factors such as noise generation and the aesthetic appearance of the pavement. The serviceability, terminal values and performance are expressed in terms of one or more of the features (e.g. the serviceability in terms of riding quality, etc.). The three most important features are listed in Table I together with the factors that determine their values and the current methods of assessment. Methods of assessing these features are discussed in the following paragraphs.

2.1 Riding quality

The riding quality of a pavement is defined as the general extent to which road users experience, through the medium of their vehicles, a ride that is smooth and comfortable, or bumpy (and thus unpleasant or perhaps unsafe). This is determined by the unevenness of the road profile (longitudinal deformation, rutting in wheelpaths, etc.), and the loss of surface material (potholes, ravelling, etc.). The value of riding quality is determined by having a panel of road users judge a pavement subjectively on a scale of 0 to 5 (where 5 indicates a perfectly smooth pavement) and taking the average rating. The sample of road users must be large enough to be representative of all road users to a desired degree of accuracy.

It is impractical to use large panels for routine assessments of riding quality. Therefore some mechanical method of measuring the characteristics of the pavement surface is required that correlates sufficiently well with panel ratings for use in practice. A number of such instruments has been developed. They are generally calibrated to agree with the panel ratings*.

Several instruments available in South Africa utilize the phenomenon that as a vehicle moves over a road with poor riding quality the body of the car will oscillate on its suspension relative to the axles. In these instruments the relative movement between the axle and the body of a vehicle or the frame of a specially made trailer is recorded, weighted according to its amplitude and summed. Riding quality values are obtained from these sums using the appropriate calibration equation. Three such instruments are:

*The term "present serviceability index" is widely used overseas to refer to a value of riding quality obtained from instruments. This term causes confusion with the wider concept of serviceability and has therefore not been included in this text. It does, however, remain a very important term when reading the literature.

- (a) **PCA roadmeter.** The movement between the rear axle and the body of a sedan car is recorded and each movement is weighted by the square of its amplitude and summed. (A version of this instrument that has been modified by the NITRR to facilitate routine monitoring of riding quality is shown in Figure 2);
- (b) **Linear displacement integrator (LDI).** This device is very similar to the PCA roadmeter. The main difference is that in this case the displacements of the rear axle with respect to the body of the vehicle are summed without being weighted by the square of the amplitude; and
- (c) **The BPR roughometer (Figure 3).** The movement between the axle and frame of a specially designed trailer is recorded and each movement is weighted by its amplitude.

The PCA roadmeter and the LDI operate at 80 km/h or 50 km/h. They can be used by road authorities* to carry out riding quality measurements at regular intervals in order to detect which roads are approaching or are below the terminal level of riding quality set for that class of road, so that a programme of effective remedial measures can be drawn up.

The BPR roughometer operates at 40 km/h. It is usually used for measuring short lengths of pavements, mainly in special investigations.

2.2 Skid resistance

Skid resistance is a term used to describe the general ability of the road surface to prevent skidding in all or particular manoeuvres generally executed by vehicles. The definition may be narrowed where required to refer to the ability of the road to allow specified manoeuvres under specified conditions. In this case one may talk, for example, of a road having a high skid resistance for cornering when wet.

The ability of a particular vehicle to execute a particular manoeuvre depends on the *coefficient of friction* between each of its tyres and the road surface during the manoeuvre. The coefficient of friction is defined as:

$$\mu = F/N$$

where F = the force developed by the friction between the surfaces and is the force by which the manoeuvre is controlled

N = the force normal to the plane of friction due to the weight of the vehicle.

The value μ is however not a constant for a particular section of road but depends on several other factors such as type of tyre, the type of manoeuvre

*As a service to road authorities, the NITRR will undertake the measurement of riding quality on request.

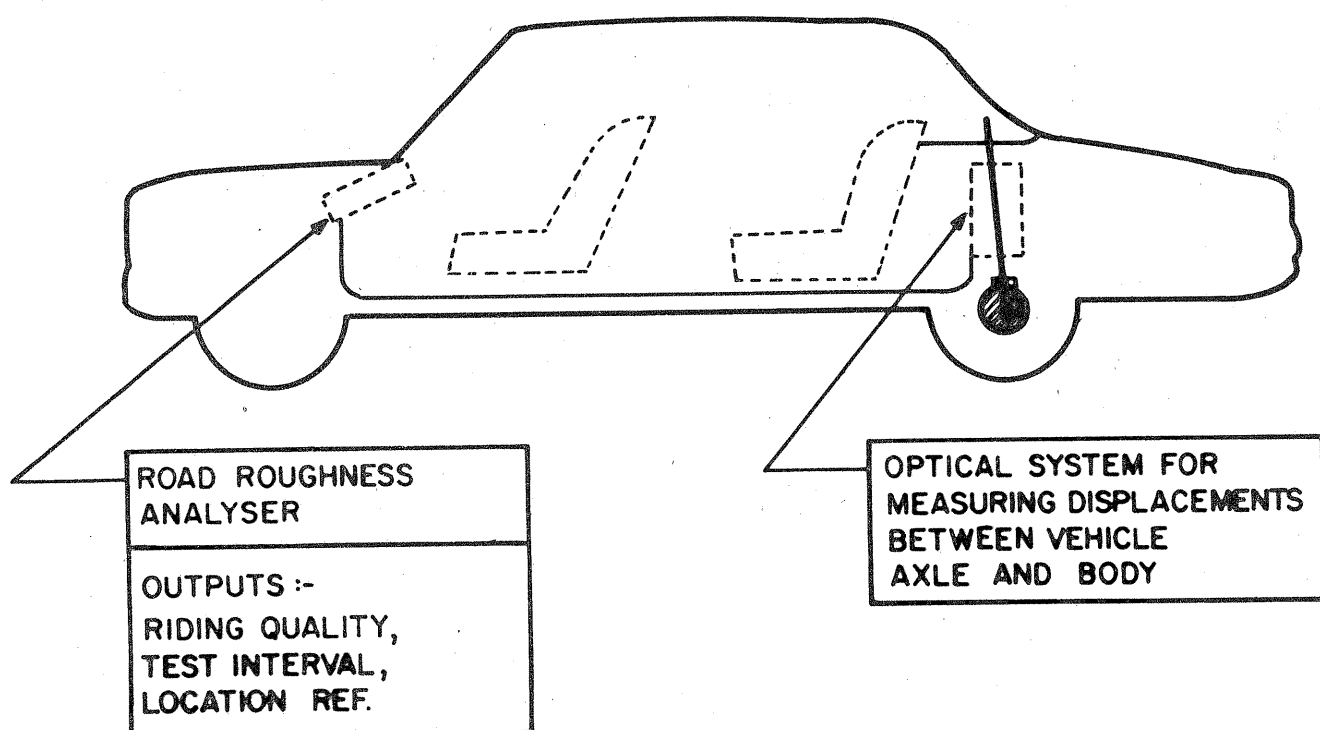


FIGURE 2

The modified PCA roadmeter

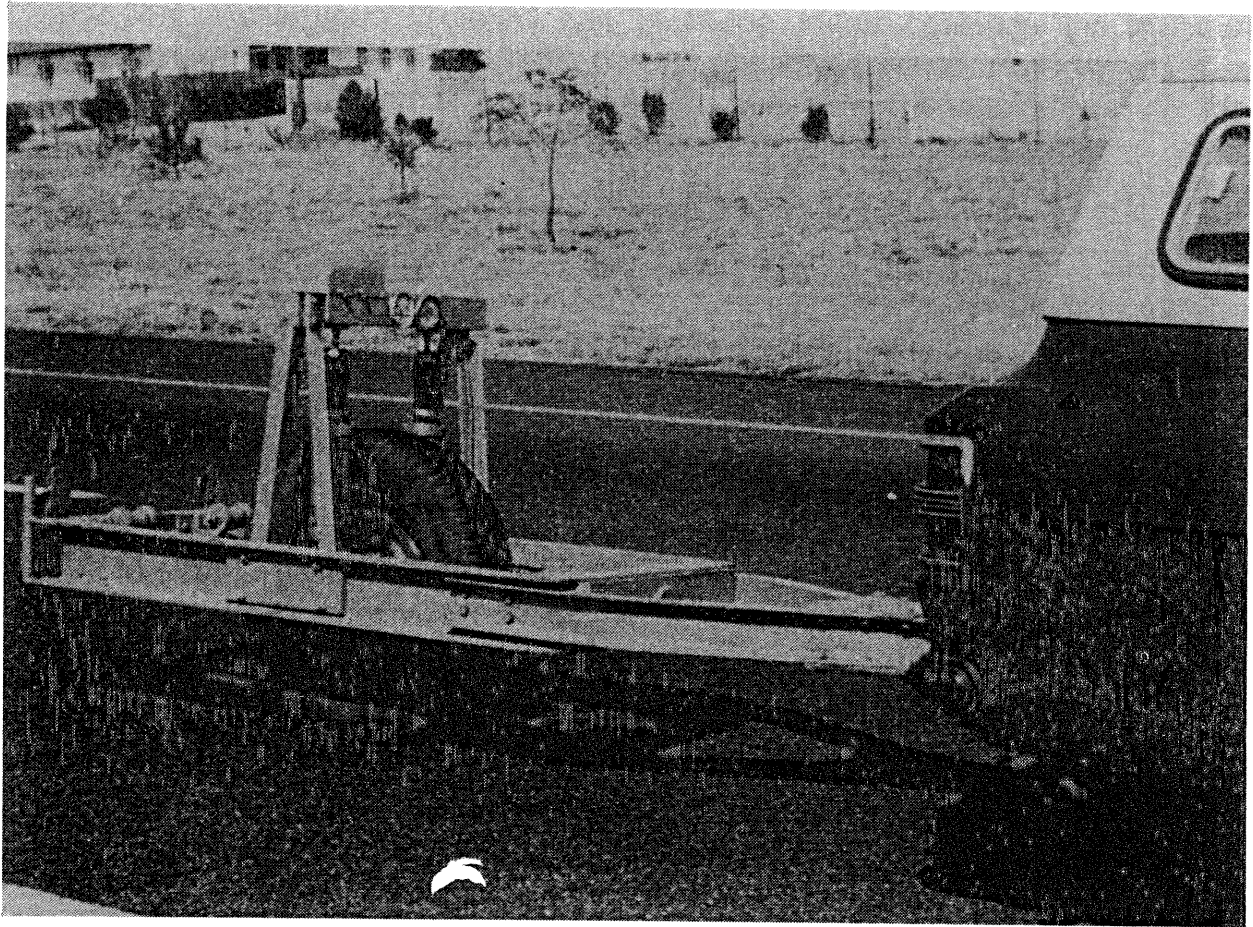


FIGURE 3

The BPR roughometer

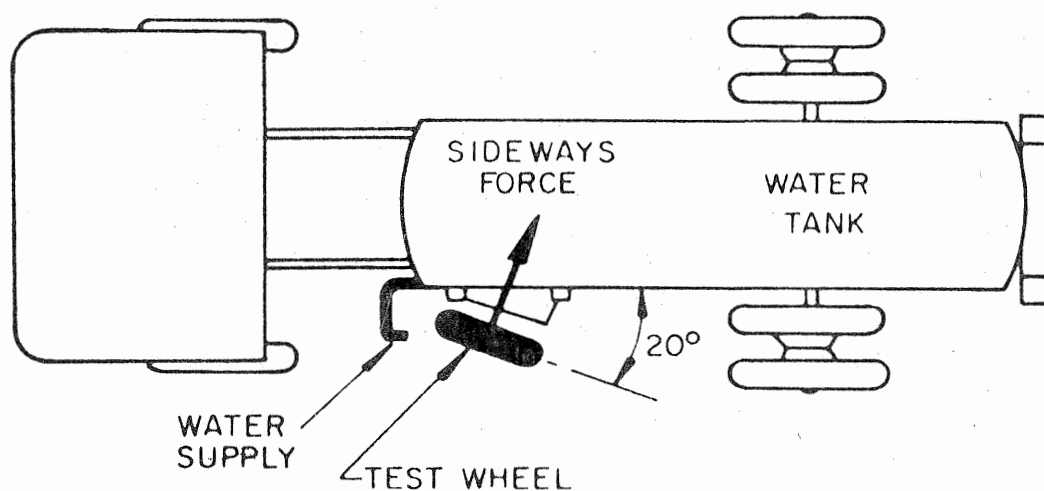
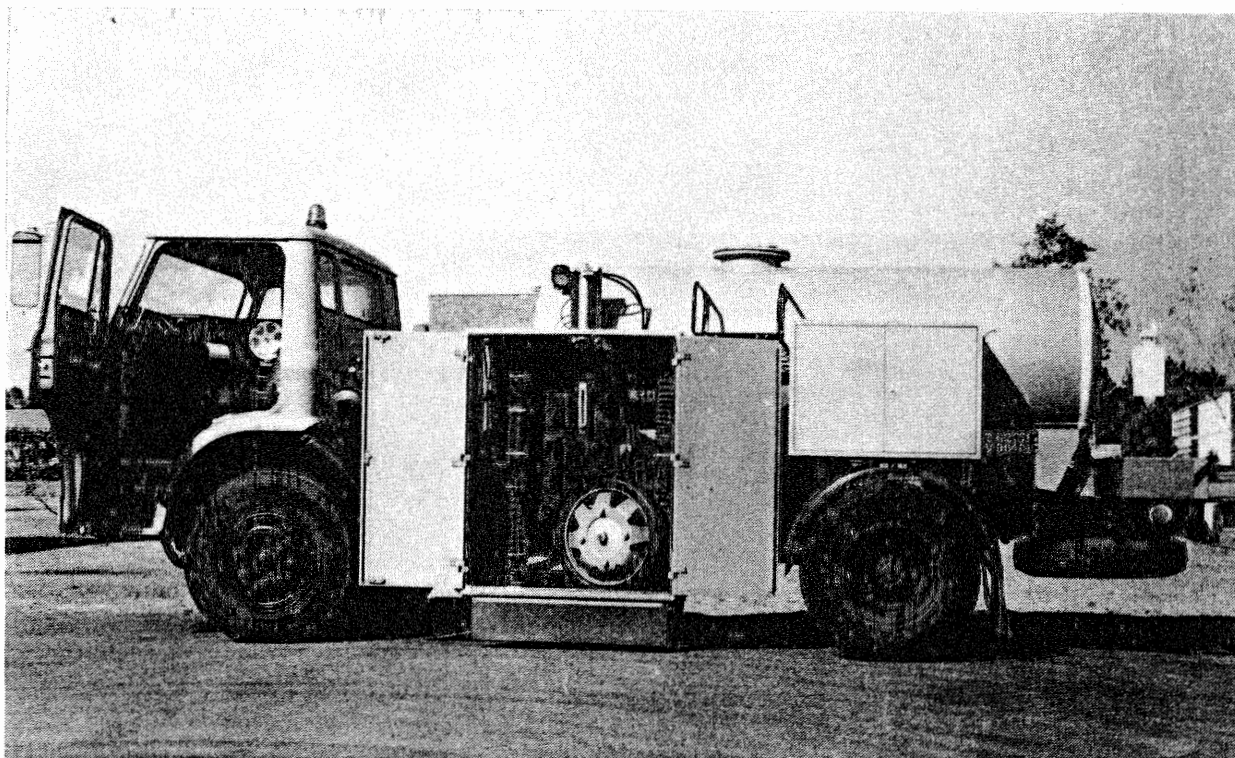
(mainly the speed and acceleration of the wheel) and on whether the surface has been lubricated (with water or oil).

Since this coefficient is not unique, the approach has been to develop instruments that can be used to estimate the average coefficient of friction that would apply to vehicles executing certain manoeuvres under wet conditions. These instruments are operated under specified and carefully controlled conditions (these are generally constant speeds and constant rates of wetting the surface of the road with water). The measurements obtained from these instruments are referred to as *coefficients of skid resistance* for the stated instrument and test conditions.

Three types of instruments are currently used in South Africa. These are SCRIM, the brake-force trailer and the pendulum tester. These are described below:

- (a) **SCRIM.** SCRIM is an acronym for sideways force coefficient routine investigation machine. It was developed at the Transport and Road Research Laboratory (TRRL) in Britain (see Figure 4). The smooth test wheel is inclined at 20° to the direction of travel. The road is wetted from the water tank on the truck and the test wheel moves continuously over this wetted surface, recording the sideways thrust exerted on the tyre by the road. The ratio of the sideways force to the normal load on the wheel is termed the *sideways force coefficient* of friction (sfc). The friction developed, and thus the sfc, may be measured continuously. Of the three instruments described, SCRIM is the most suited to routine measurements of skid resistance*.
- (b) **Brake-force trailer.** This is a single-wheel trailer device for measuring brake force. It is shown in Figure 5. It is towed by a light delivery vehicle which carries a supply of water sufficient for about 25 tests. At the test speed the smooth tyred wheel is locked for about 2 seconds over the wetted surface. The purpose of this short test period is to limit wear of the tyre. The braking force is measured by strain gauges and the ratio of the braking force to the normal load on the wheel is called the *brake force coefficient* (bfc). The brake-force trailer is unsuited to routine measurements. It is mainly used for research or for investigating special cases for which this method of testing is more applicable.
- (c) **Pendulum tester.** The portable pendulum tester, also developed by the TRRL, is shown in Figure 6. The instrument is set up so that the rubber slider attached to the pendulum moves over a specified length of the surface of the pavement. The pendulum swings from a horizontal, rest position and the energy loss that occurs as it moves over the surface is a measure

*The NITRR undertakes the measurement of skid resistance with SCRIM as a service to the road authorities.



$$\text{SIDEWAYS FORCE COEFFICIENT (SFC)} = \frac{\text{SIDEWAYS FORCE}}{\text{VERTICAL REACTION AT TYRE/SURFACE INTERFACE}}$$

FIGURE 4

SCRIM

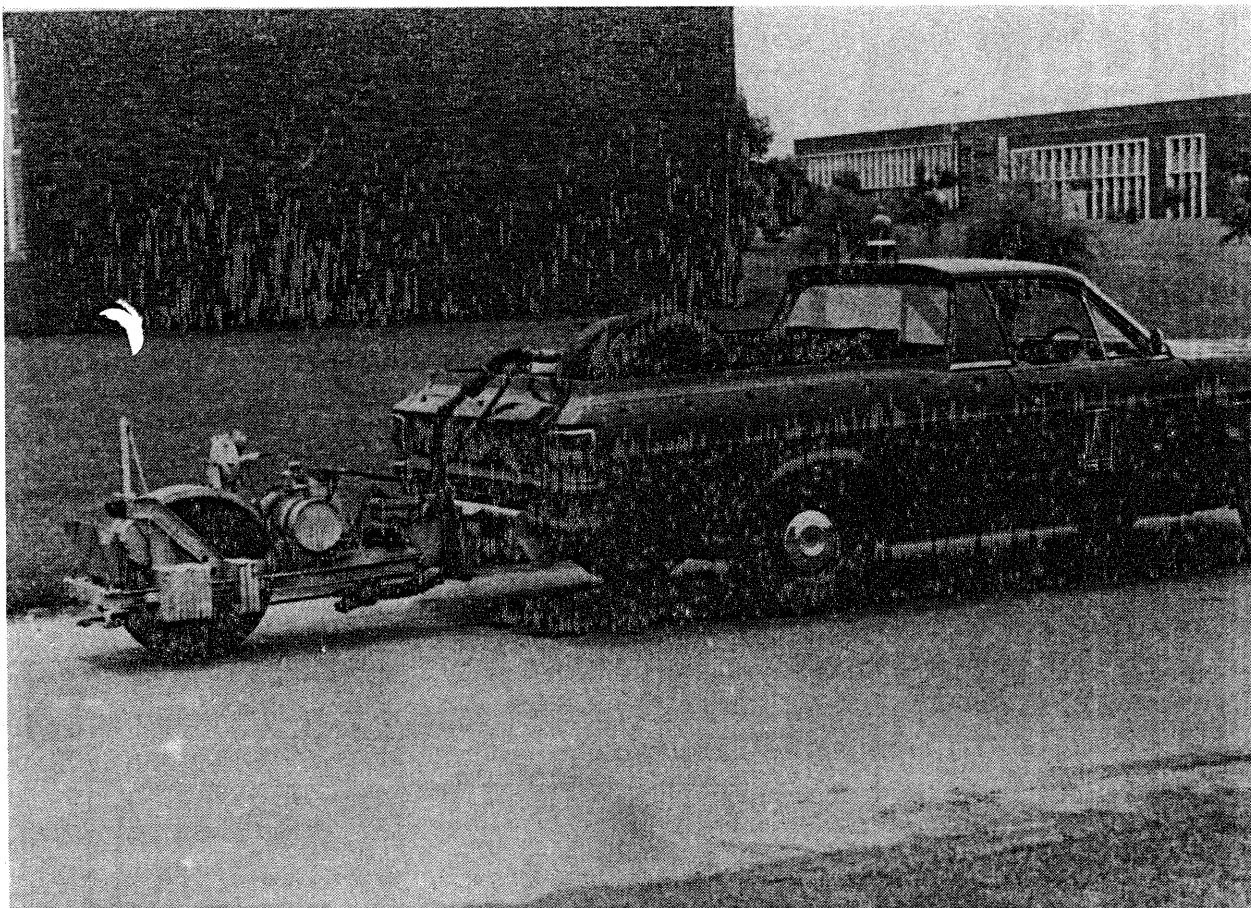


FIGURE 5

Brake-force trailer

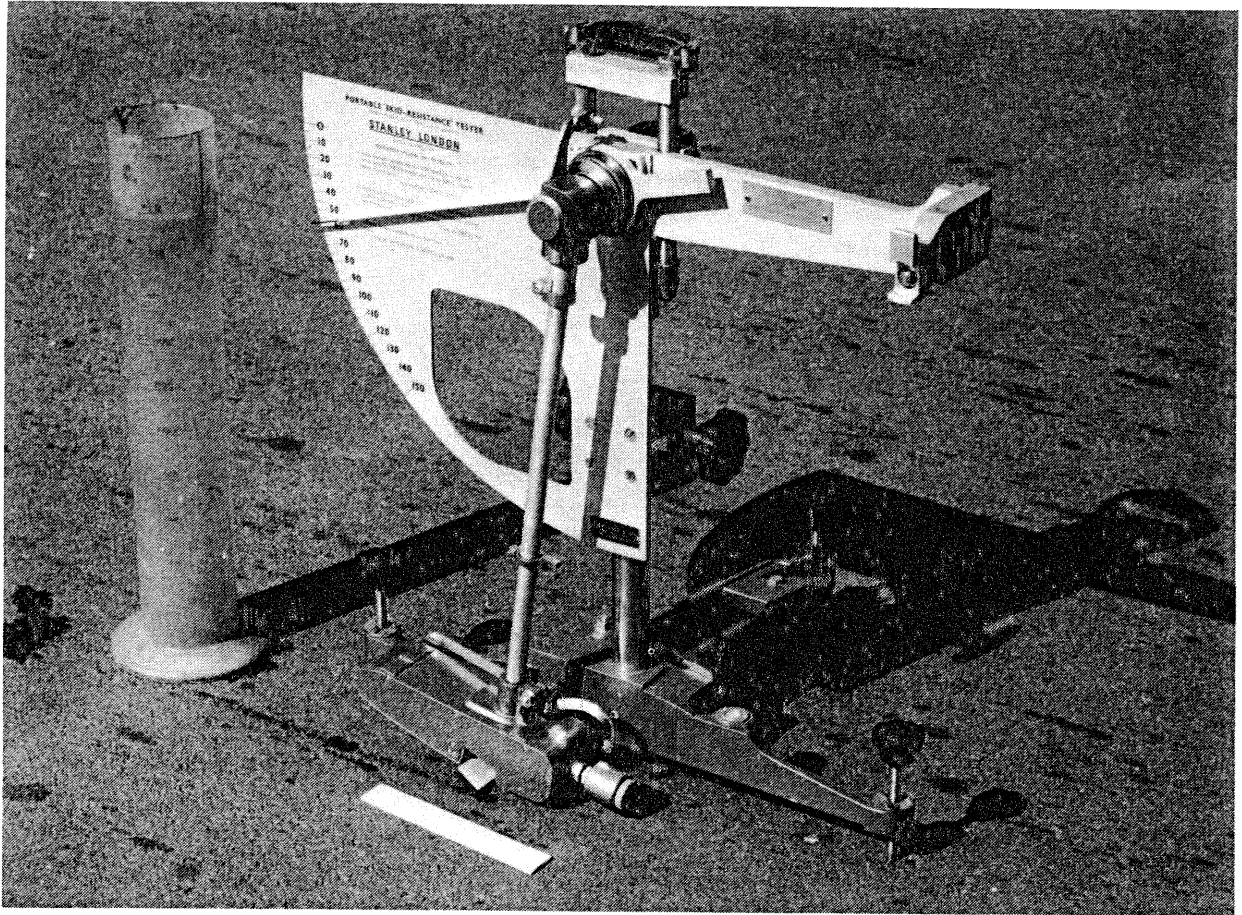


FIGURE 6
The pendulum tester

of the friction. This is read off directly from a calibrated scale. This instrument can be used to obtain an indication of the skid resistance for stopping from low (≈ 50 km/h) speed but it is entirely unsuited to routine surveys.

The property of the pavement that has the major effect on its skid resistance is the roughness of the surface on a scale commensurate with the dimensions of the contact area between the pavement and the vehicle type, i.e. the surface texture. The two important characteristics of the surface texture that contribute to the skid resistance are the macrotexture and the microtexture.

The *macrotexture* relates to the gaps between the stones protruding from the surface. These allow water to escape from between the tyre and the road surface. This property is measured in terms of the *surface texture depth* by spreading a known volume of sand over the surface, measuring its area and calculating its average depth. This test is known as the sand patch test.

The *microtexture* relates to the harshness or roughness of the stones themselves. There is currently no direct quantitative measure of the microtexture, but this can be qualitatively assessed by examining the stones and determining if they are harsh and angular or smooth and rounded (stones which are smooth have generally become so through the polishing action of traffic and are thus said to be *polished*). Stones that are resistant to polish have a high *polished stone value* (PSV).

The macrotexture is of overriding importance at high speeds (> 100 km/h) whereas the microtexture is of overriding importance at low speeds (< 50 km/h). Since the pendulum tester is an appropriate instrument for measuring skid resistance for low speeds, it follows that it also provides an indirect measure for the microtexture.

As with the procedure used with riding quality, coefficients of skid resistance can be monitored at regular intervals in order either to evaluate the performance of various surfacings in terms of their skid resistance, or to identify roads which need to be considered for an improvement of skid resistance.

2.3 Surface drainage

The *surface drainage* of a road is a measure of the general ability of the road to keep its surface clear of water. This refers to the speed at which water runs off during rain and to the extent of ponding of water during and after rain. The former determines the film thickness of the water on the road which is an important factor affecting the skid resistance whereas the latter is a hazard in the form of water thrown up, especially by fast moving traffic. The function of good surface drainage is also to keep the road surface clear of grit washed onto the road from the verges. Figure 7 gives an example of a section of road covered with grit and with ponding of water.

The surface drainage is determined by the crossfall of the surface, the presence of any deformation of the surface, the capacity of the drainage system and the

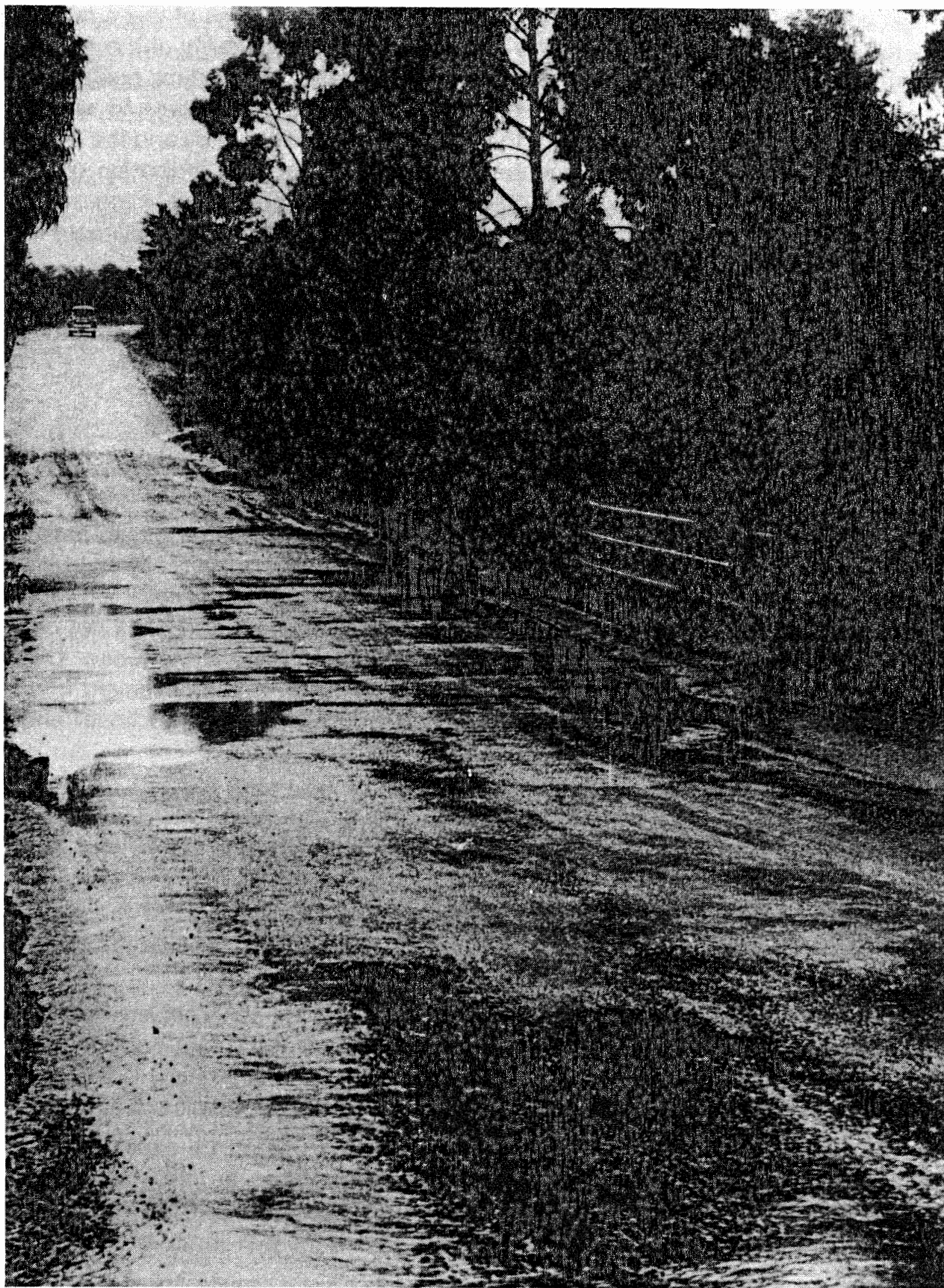


FIGURE 7

A section of road with poor surface drainage

drainage characteristics of the adjacent land. The effectiveness of these factors in facilitating surface drainage is the measure of the serviceability of the road in terms of surface drainage. No means have yet been determined for quantifying the effectiveness of drainage, although design requirements are given by several authorities. Often an assessment of the condition of the shoulders and the drainage paths away from the pavement surface can give a good indication of the surface drainage. Terminal levels of surface drainage are usually determined subjectively by inspection during rain taking into account the rainfall characteristics of the area.

Note that ponding of water on the surface is also undesirable in that it allows time for water to penetrate through the surface into the pavement structure. However, this consideration is not important in a functional evaluation.

3 STRUCTURAL EVALUATION

The object of assessing the condition of existing pavements is usually to determine what action is required to keep them serviceable as economically as possible. Even if the serviceability is satisfactory at the time of the assessment, the pavement may still require maintenance in order to ensure that it does not become damaged and demand much more costly maintenance in the future. This means that it is necessary to predict the future condition of the pavement from current assessments which must take into account both the functional and structural properties.

The trend of the condition over a period of time is called the *behaviour* of the pavement* (i.e. behaviour is the function of condition with time). The factors that determine the behaviour of a particular pavement are the traffic forces and environmental factors acting on it. The structure is therefore evaluated with a view to determining its resistance to traffic and the environment. Accordingly the *structural capacity* of the pavement is defined as the ability of the pavement to withstand the effects of traffic and environmental forces.

In principle a knowledge of the structural capacity and the serviceability, the environment and the expected traffic are used to predict the future behaviour of the pavement under alternative maintenance strategies. That strategy is then selected that is most suitable with respect to functional and economic criteria.

In practice, however, the structural condition cannot usually be expressed directly in terms of the structural capacity but is described in terms of related properties of the pavement structure. These are the so-called *structural indica-*

*Note that just as the serviceability is a special feature of the overall condition of the pavement, so the performance is a special feature of the overall behaviour. One can also refer to the behaviour in terms of one or more aspects of the condition, such as deflection, cracking, etc.

tors of which there is a large variety and often several ways of expressing each of them. The use of such indicators depends on which of the various possible approaches and models is chosen for predicting the behaviour of the pavement. Several classes of these indicators are listed in Table II and discussed below:

- (a) **Structural reaction.** By this is meant the stresses and strains induced in the pavement by a load on the surface. Measures of the structural reaction are deflection, radius of curvature, etc. If the strains caused by a standard load are generally relatively low throughout the structure, the pavement is said to be *stiff* or to have a high *stiffness*.

TABLE II
Indicators of structural condition

TYPE	MEASURED/JUDGED BY
1. Structural reaction	Deflection Radius of curvature Elastic moduli Layer thicknesses
2. Material properties	Stability Fatigue Plasticity index CBR
3. Structural integrity	Porosity Cracking of stabilized layers
4. Drainage	Crossfall Culvert capacity Efficiency of subsurface drainage
5. Distress	Deformation Cracking Disintegration of surfacing Smoothing of surface texture
6. Structural response	Accelerated behaviour (Heavy Vehicle Simulator) Past behaviour (Normal traffic and environment)

- (b) **Material properties.** Material properties are measures of the way in which materials in the pavement respond to stresses, strains and the presence of water. These are either direct measures of response such as fatigue life, polished stone value, porosity, etc., or properties that characterize materials by which the response can be inferred, such as density, grading, etc.; or hybrid cases, such as CBR and plasticity index, where it is not clear whether the properties represent a response or a characterization of the material. Properties of materials that specify the conditions under which their response is satisfactory are called *delimitative* properties. These include, for example, fatigue life relationships of asphalt mixes and the crushing strength of aggregates.
- (c) **Structural integrity.** The pavement can be seen as a system of interrelated components. The integrity of the structure refers to the soundness of this system from this point of view, whereas the integrity of the component refers to the degree to which that component fulfils its role in the system. The structure loses integrity if part of the system is damaged or deteriorates so that the system's structural capacity is reduced. The components of the pavement are usually taken as the subgrade and the constructed layers (see Figure 8). These layers lose integrity if they crack, become more porous (or less porous in some situations), deform, etc. (The components may *yield* under stress, deteriorate or be damaged and the structure will lose integrity.)
- (d) **Drainage.** This is a measure of the ability of the structure to drain water from the pavement. It is judged by measurements of the crossfall of the surface and culvert capacities and estimations of the *efficiency* of subsurface drainage.

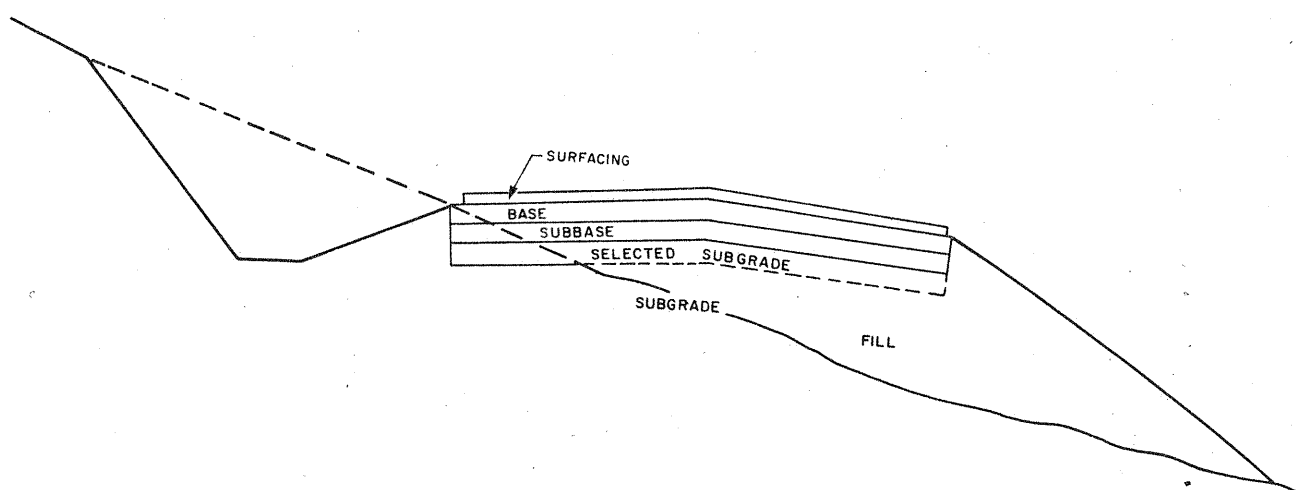


FIGURE 8

Components of the pavement structure

- (e) **Distress.** Distress is the visible manifestation at the pavement surface of the deterioration of the condition of the pavement with respect to either the serviceability or the structural capacity. The measurement of distress is usually convenient since it does not require instruments. Distress is also particularly important as a structural indicator because it clearly identifies weaknesses in the pavement. For these reasons detailed attention is given to concepts used in the classification of the appearance and distribution of distress in Appendix A.
- (f) **Structural response.** This is the response of the pavement (i.e. change in its behaviour) to some form of input to the pavement system. Examples are an analysis of the past behaviour of the pavement under known traffic and environmental inputs and accelerated trafficking with the Heavy Vehicle Simulator.

An expression of the structural indicators alone simply constitutes a description of the condition. An evaluation of the structural condition requires some model which relates the separate factors. Such an evaluation may be an assessment of the structural capacity, the structural strength or the structural adequacy of the pavement or its maintenance requirements. Here the *structural strength* of the pavement is related to the difference between strains that can be tolerated by the materials in the pavement and the strains imparted to them by a standard axle load under existing environmental conditions. (It thus expresses the resistance of the pavement to traffic, especially accelerated trafficking and can thus be regarded as an aspect of the structural capacity. Overlaying a pavement will therefore invariably improve the structural strength but not necessarily the structural capacity.) The *structural adequacy* is an assessment of whether the pavement requires strengthening or maintenance or whether it is adequate to meet the predicted traffic and environmental demands during the period before the next assessment. In addition to the physical aspects of the pavement such an assessment has to take into account the financial situation and the policies of the road authority. Often the structural adequacy is determined by comparing various structural properties against specified critical values or standards which are set according to traffic, policy, etc. The use of critical values of condition of a pavement is discussed in the following section.

4 CRITICAL VALUES OF PAVEMENT CONDITION

Terms such as "failure criteria", "failed condition", "the road has failed" are commonly used in practice and in the literature without clear definitions of their meanings always having been given. To say a road has failed generally suggests that some distress is evident on the road but does not usually indicate the seriousness of the distress. In some cases it does imply that maintenance measures are immediately required for the road. Failure criteria or failure conditions

usually refer to some critical level of distress with respect to some purpose for which the condition is being evaluated. these purposes may be the study of a pavement from a functional, structural or research point of view. Strictly speaking then, a pavement fails (to meet acceptable standards) if it deteriorates beyond some critical level which must be specified or at least implied in the context of the assessment. Various types of critical values are discussed in the following:

Terminal levels of serviceability are critical values of the pavement condition that provide minimum tolerable levels of comfort, safety or speed for the road user. If the serviceability of a pavement is below the acceptable level for the particular class of road, this defines a need for that pavement with respect to user requirements. Specifically one may refer to terminal levels of riding quality, skid resistance or surface drainage.

On the other hand a pavement may receive maintenance long before it has reached the terminal level of serviceability. This would be because the state of distress and the particular traffic and environmental conditions are such that it would be more costly to implement some major maintenance in the future than the relatively minor maintenance needed earlier to arrest the development of distress. That level of distress at which it is the most economical to maintain the pavement is defined as the *critical state of distress* with respect to maintenance. If the pavement is left until the distress increases beyond the critical state, the pavement can be said to be in a *severe state of distress*.

In research, pavement designs are often compared on the basis of the number of repetitions of a standard axle load that is required to produce a specified condition of the pavement, the *terminal condition* of the pavement for the purposes of the experiment.

ATTRIBUTES OF DISTRESS

A.1 INTRODUCTION

The appearance of distress is very varied and often extremely complex. The task of describing this is achieved by recording its main characteristics - the so-called attributes of distress. These are the location, mode, type, degree, extent, spacing and position. These attributes are defined below where methods are given for expressing the values of each of the attributes. For some of the attributes there are alternative ways of doing this and it is left to the engineer to decide which method is most suited to his requirements. In addition to describing the appearance of the distress it is often important also to indicate how the distress came about. This is expressed in terms of the mechanism and cause of distress. These expressions are also defined below.

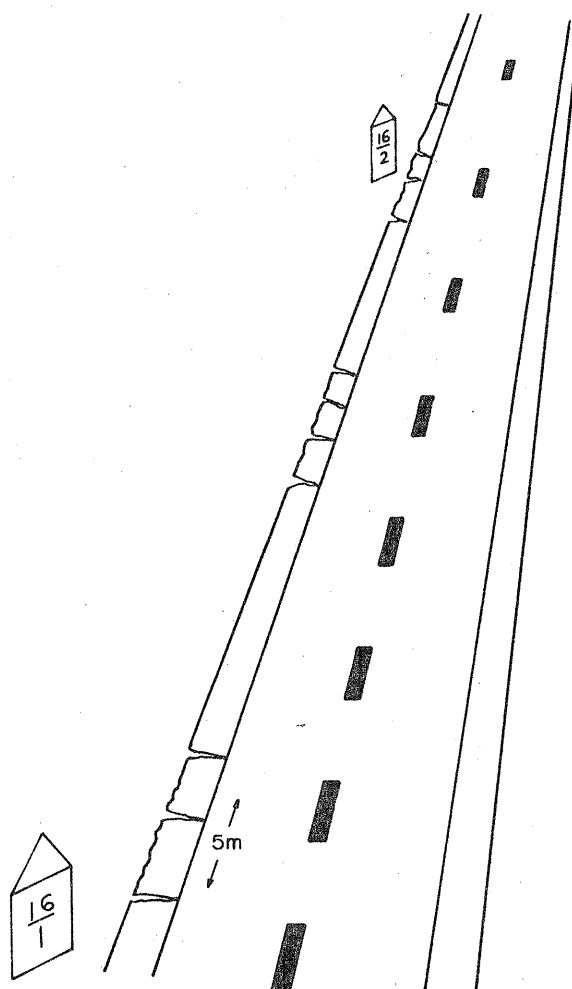
A.2 ATTRIBUTES

The various attributes defined in this section are illustrated in Figure 9 for the case of a pavement with transverse cracks.

- (a) **Location.** The *location* of distress is given in terms of two points along the length of the pavement. These points delineate a pavement section to which the subsequent description of distress pertains. These points are chosen on basically pragmatic grounds. They may represent an experimental pavement section, a length of road to be overlaid, or a unit length of pavement for monitoring purposes in a pavement management system. Generally if the sections are too long the description of distress becomes imprecise, whereas the division of the pavement into very short sections makes the task of recording distress tedious and expensive.
- (b) **Modes and types.** There are four major ways in which distress occurs. These are called the *modes* of distress. They are:
 - (i) Deformation. This is the development of a change in the profile of the surface of the pavement (unevenness).
 - (ii) Cracking. This refers to the cracks that appear in the surface of the pavement.
 - (iii) Disintegration of the surfacing. This is the break-up and loss of the surfacing. It can occur through spalling of the material at cracks or edges of the pavement or through the crumbling and loss of material at the surface by the abrasive action of traffic.
 - (iv) Smoothing of the surface texture. This is the loss of surface texture which leads to a loss of skid resistance.

Each of these modes of distress can occur in one of several different typical manifestations. These are called the various *types* of distress. For example

cracking can be classified as crocodile cracks, transverse cracks, etc. and deformation as ruts, depressions, corrugations, etc. In the following section the various types of distress are defined and the methods for rating their attributes are given where they differ from one type of distress to the next. The modes and types of distress are summarised in Table III.



LOCATION : ROAD R29 -1, 16,1 km to 16,2 km
 MODE : CRACKS
 TYPE : TRANSVERSE CRACKS
 DEGREE : DEGREE 5 (5mm CRACK WIDTH)
 EXTENT : LENGTH 40 %
 SPACING : 5 m
 POSITION : SHOULDER

FIGURE 9

Illustration of attributes of distress for a pavement with transverse cracks

TABLE III*Various types of distress associated with each mode of distress*

MODE OF DISTRESS	TYPE OF DISTRESS
Deformation	Depressions Mounds Ruts Ridges Displacements Corrugations Undulations
Cracking	Transverse cracks Longitudinal cracks Block cracks Map cracks Crocodile cracks Parabolic cracks Star cracks Meandering cracks Multiple cracks
Disintegration of surfacing	Ravelling Potholes Edge breaks Patches
Smoothing of surface texture	Bleeding Polishing

- (c) **Degree and extent.** The *degree* of a particular type of distress is a measure of how bad it is *at a particular point* on the road (which means that the degree of distress can vary over the pavement section). For example the degree of cracking is a function of the width of the cracks. The degree is indicated by a class number where Degree 1 indicates the first evidence of a particular mode (and type) of distress and Degree 5 indicates the worst degree. The standard way in which the degree of each type of distress is classified is given below. These can be quite complex. However, Table IV indicates roughly what each class would signify for "typical" pavements in "average" environment and traffic conditions. This is meant only as guide to the frame of "reference" against which the classes were defined. Note that in line with this definition a condition "Degree 1" will in practice normally be coded as "no distress". This classification provides a useful standard for

TABLE IV
Classification of the degree of distress

CLASS	DESCRIPTION
Degree 1	Distress difficult to discern visually
Degree 2	Easily discernible distress but of little immediate consequence
Degree 3	Notable with respect to possible consequences
Degree 4	Important with respect to possible consequences
Degree 5	Extreme with respect to possible consequences

coding distress. However, the option is also open for expressing the degree in terms of direct measurements (e.g. a crack of 3 mm width).

The *extent* of distress is a measure of how widespread the distress is over the pavement section. Usually it is expressed in terms of what proportion of the pavement has a particular type of distress in excess of a given degree. This can be given by expressing either the proportionate *length* or *area* of the pavement affected. (For example, Cracking Degree 3 Area 40 per cent means that 40 per cent of the area is cracked to Degree 3 or more, and Cracking Degree 4 Length 30 per cent means it is cracked over 30 per cent of its length - to Degree 4 or Degree 5.) A further useful measure of extent, especially for rapid inspection surveys, is the *number* of affected areas in the section of pavement under review. An affected area is a localized area of distress within the pavement section. The average size of such affected areas is given by the spacing parameter as defined below.

It is often of interest to describe cases where the degree of a certain type of distress varies considerably over the pavement section. This is expressed by giving the extent for increasing degrees of distress. For example, Degree 2 Area 80 per cent and Degree 4 Area 10 per cent indicates that approximately 80 per cent of the road was in a state of distress of *at least* Degree 2 (i.e. Degree 2 and greater) and that within this 10 per cent of the road was of Degree 4 and greater.

- (d) **Position and spacing of distress.** The *position* of distress refers to where the distress is situated transversely across the pavement. The various options include: the wheelpaths, the shoulder, the edge, the centre line, etc.

The *spacing* of distress is an additional parameter indicating the geometry of the distress. Its definition varies for the different types of distress but it always represents a linear measurement. For example for transverse cracks the spacing indicates the average distance between the cracks.

A.3 AUXILIARY CONCEPTS

A.3.1 Cause and mechanism of distress

The cause of distress refers to an extraordinary circumstance or condition which was necessary for the distress to occur. Examples of causes are intrusion of water (through, for example, inadequate drainage), unstable materials, excessive loading, under-design and hardening of the binder.

The mechanism of distress is the physical process by which the cause results in the manifestation of the distress. Examples of mechanisms of distress include shear, heave, consolidation, fatigue, shrinkage, plastic flow and pumping.

The identification of the cause and mechanism of distress often plays an important part in the structural evaluation of the pavement, i.e. in assessing its structural capacity and determining its maintenance requirements.

A.3.2 Pavement components

In explaining the cause and mechanism of distress it is usually necessary to refer to one or more of the components of the pavement. These are the shoulders, surfacing, base, subbase, subgrade and fill. They are illustrated in Figure 8.

A.3.3 Primary and secondary distress

Often one type of distress is a result of some other initial distress. In such cases the initial distress is defined as *primary distress* and all consequent distress as *secondary distress*.

A.3.4 Structural and surface distress

When evaluating the design of a pavement, it is often convenient to differentiate between the *structural* distress and *surface* distress of the pavement. Structural distress is the type of distress that pertains to the load-bearing capacity of the pavement in either origin or consequence. Surface distress is that distress that pertains only to the abrasion and skid resistance of the surface and which therefore can be remedied completely by a thin resurfacing. Specifically it includes ravelling of the surface and smoothing of the surface texture. There are several types of distress that are not uniquely classified in this way and the choice should be made within the context of the particular circumstances.

A.3.5 Severity of distress

The *severity* of distress is a measure of how serious the distress is especially in terms of maintenance. In general it has to take into account all the properties defined above. A scale cannot be defined for severity, firstly because there is incomplete knowledge of the relative importance of the various properties and secondly, the relative importance depends on external factors such as those of traffic and climate. The term is therefore generally used in a qualitative or relative sense.

A.4 CLASSIFICATION RULES FOR EACH DISTRESS TYPE

A.4.1 Deformation

A.4.1.1 Types

Deformation is a change in the road surface profile. This is manifested as an area of the pavement having its surface either above or below that of the original level. The various types of deformation are defined as follows:

- (a) **Depressions.** Depressions are localized areas of pavement with an elevation lower than that of the surrounding area.
- (b) **Mounds.** Mounds are localized areas of pavement with an elevation higher than that of the surrounding area.
- (c) **Ruts.** Ruts are depressions extended in length and confined in width. These usually occur in a longitudinal direction and in the wheelpath.
- (d) **Ridges.** Ridges are mounds extended in length and confined in width.
- (e) **Displacements.** Displacements are mounds adjacent to depressions, i.e. where the surface in section has the typical form shown in Figure 10. This usually occurs when material in a weak pavement layer is displaced laterally through shear forces induced by traffic.
- (f) **Corrugations.** Corrugations are regularly spaced transverse undulations of the pavement consisting of valleys and crests less than 1 m apart.
- (g) **Undulations.** This is a non-localized, undulating form of deformation - of the type usually associated with active subgrades or the settlement of an embankment.

A.4.1.2 Degree

The degree of deformation is measured in terms of the maximum deviation under a 2 m straight-edge as illustrated in Figure 11. If a straight-edge of a different length is used, this should be noted. Such measurements are normally only

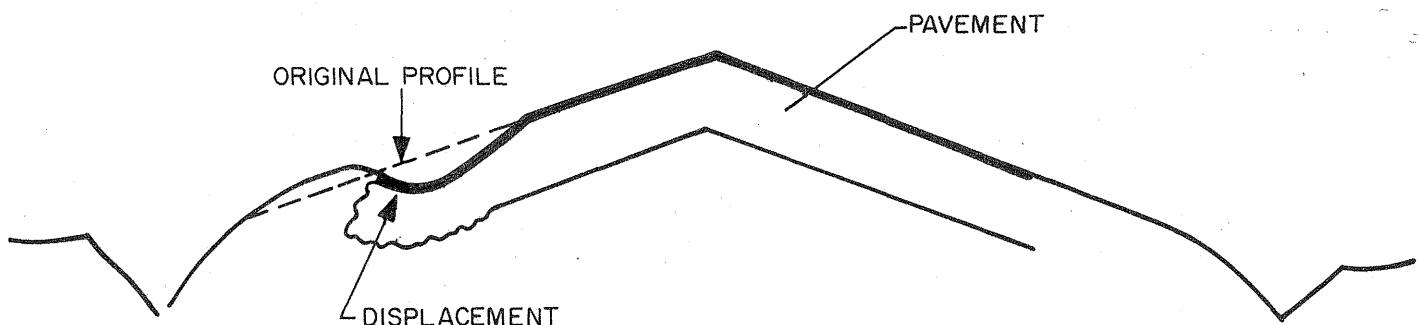


FIGURE 10

Illustration of a displacement

taken for rutting and for depressions of special interest. The degree can be expressed directly in millimetres or in terms of one of the following classes:

Degree 1 – Less than 5 mm

Degree 2 – 5 to 10 mm

Degree 3 – 10 to 20 mm

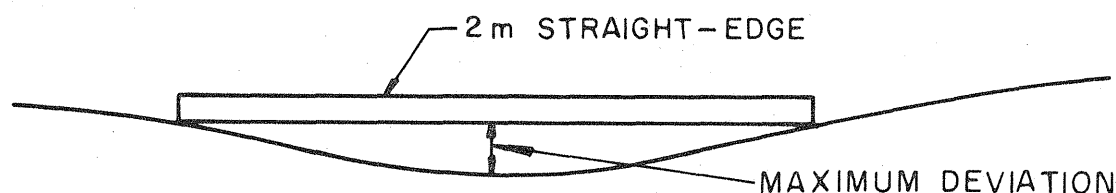
Degree 4 – 20 to 40 mm

Degree 5 – Greater than 40 mm

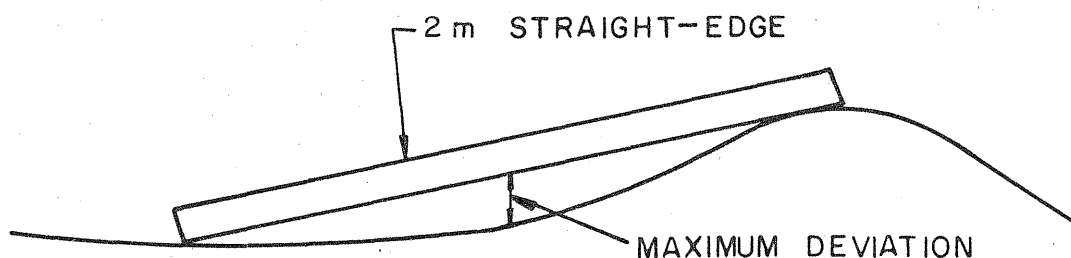
A.4.1.3 Examples

Figures 12 to 17 illustrate various examples of deformation. Indications are given of various attributes and the probable cause and mechanism where possible and appropriate.

NOTE: It is often not necessary or even pertinent to describe the deformation in terms of depressions, mounds, etc. It may be sufficient to express it simply in terms of the riding quality of that section of pavement (see Section 2.1). Care must therefore be taken in determining which type of description best suits the purpose of the inspection.



(a) THE MEASUREMENT OF A DEPRESSION



(b) THE MEASUREMENT OF A MOUND

FIGURE 11

The method of measuring the degree of deformation

A.4.2 Cracking

A.4.2.1 Types

- (a) **Transverse cracks.** Line cracks transversely across the pavement. (They are often a manifestation of shrinkage in a cement-stabilized base or sub-base.) The spacing of transverse cracks is the average distance between cracks.
- (b) **Longitudinal cracks.** Line cracks running longitudinally along the pavement. (Especially if near the edge these may be a sign of shrinkage in an underlying active clay subgrade. They may also be a manifestation of shrinkage in a stabilized base or subbase, where they are often located along pavement joints. In an irregular crescent pattern, they may be a sign of yielding or settlement of an embankment. In pavements exhibiting marked rutting, they may be an indication of excessive strains caused by deformation.) The spacing of longitudinal cracks may be given as the distance between two parallel longitudinal cracks where applicable.
- (c) **Block cracks.** Cracks in a block or rectangular pattern. The spacing is given as the average of the shorter distance between the sides of the blocks. (Where the spacing is about four to five metres the block cracking usually occurs through a combination of transverse and longitudinal cracking - often by the shrinkage of a stabilized base or subbase.)
- (d) **Map cracks.** Cracks in an irregular polygonal pattern of an average diameter greater than 300 mm. (These can occur through hardening of the binder and subsequent thermal shrinkage of the surfacing or through shrinkage of an unbound gravel base.) The spacing of map cracking is the average diameter of the polygons.
- (e) **Crocodile cracks.** Cracking in a polygon pattern where the average diameter (spacing) is less than 300 mm and resembling the skin of a crocodile. (It may occur directly through fatigue of the surfacing due to the action of traffic or as secondary cracking around primary line cracks. Other causes are also possible.) Crocodile cracking often occurs in localized areas. In such cases it may be convenient to express the extent of cracking as the number of such cracked areas and use the *spacing parameter to indicate the average length* (i.e. diameter in a longitudinal direction) *of these areas*. If this method is chosen it must be clearly presented otherwise confusion may arise as to the use of the spacing parameter.
- (f) **Parabolic cracks.** Cracks of a parabolic shape (usually caused through the slippage of the bituminous surfacing due to the horizontal forces of traffic and therefore more common on sections where rapid acceleration or deceleration takes place on steep up or down grades.)
- (g) **Star cracks.** Cracks radiating from a point (occur through blistering due to the accumulation of material e.g. salt, beneath the surfacing or as a first stage in crocodile cracking).

- (h) **Meandering cracks.** Line (i.e. not polygonal) cracks running in random directions.
- (i) **Amorphous (multiple) cracks.** Cracks of variable or undefined pattern (for example as illustrated in Figure 28) which could be the result of the superimposition of more than one of the common crack patterns.

A.4.2.2 Degree

The classes of degree are:

Degree 1 – not visibly cracked

Degree 2 – faint cracks

Degree 3 – distinct cracks (i.e. easily observable when walking at reasonable pace)

Degree 4 – open cracks with width less than 3 mm

Degree 5 – open cracks with width more than 3 mm or with spalling

Spalling is defined here as the crumbling of the surfacing material in and about the cracks.

A.4.2.3 Extent

In addition to the standard measures of extent, the extent of cracking can be given in terms of *the length of linear cracks* (i.e. the sum of all individual crack lengths). This is a pertinent concept but it is difficult to assess directly in the field. It can, however, be estimated from type, extent and spacing parameters.

A.4.2.4 Position

The location of cracks on a carriageway may be specified, e.g. in the wheel-tracks, the shoulders or the riding surface.

A.4.2.5 Examples

Figures 18 to 31 illustrate various types of cracking. Indications are given of various attributes of the distress where applicable.

A.4.3 Disintegration of surfacing

The disintegration of the surfacing occurs when the surfacing material is broken up and lost. This is manifested in four ways: ravelling, potholes, edge breaks and patches. These four distress types and their attributes are defined in the following:

A.4.3.1 Ravelling

Ravelling is the crumbling and loss of material at the surface of the pavement, usually through the abrasive action of traffic. In the case of thin surface treatments this results in exposure of the underlying layer and if this is an unbound layer potholing follows. In the case of an asphalt surfacing, the surfacing gradu-

ally disintegrates after which it eventually cracks, spalls and develops potholes. The onset of ravelling is often preceded by a loss in the adhesion or ductility (i.e. hardening) of the binder which can sometimes be identified by a "dry" appearance of the surfacing. This phenomenon, however, depends greatly on other factors such as temperature; it cannot easily be determined by general visual classification but requires assessment by experienced personnel.

- (a) **Degree.** A single seal consists of one layer of single-size stone and consequently any loss of stone exposes the underlying layer directly. A multiple seal consists of several layers of stone of successively smaller size and ravelling is characterized by the loss of the fine stones on the surface followed by the loss of the larger stones in successively exposed layers. An asphalt surfacing consists of a mixture of stones of various sizes. The fine stones on the surface are lost first, followed by the loosening and loss of the larger stones. This is repeated as the asphalt layers disintegrate. Because of the different manifestations of the distress in different surfacings, the degree of ravelling is defined differently for each case and therefore care must be taken when coding this to record the type of surfacing inspected.

The degrees of ravelling are defined in Table V.

In view of the complexity of coding the degree of ravelling, there may be cases where it is more suitable to express the degree in terms of a description rather than a symbol.

- (b) **Extent and spacing.** In order to describe the appearance of ravelling adequately, it will often be necessary to indicate its extent by both the "length" and the "area" attributes. The length attribute indicates the proportionate length of the pavement affected whereas the area attribute indicates the proportion of the area affected, i.e. the "percentage stone loss". The additional use of the length attribute distinguishes between a given percentage stone loss localized within a pavement section or distributed evenly over the section.

The spacing is defined as the average diameter of the patches in which stone has been lost. For example ravelling of a single seal described as:

Degree 5 Area 1 % Length 10 % Spacing 10 mm

indicates that stone was lost over 10 per cent of its length, overall one per cent of the stone was lost (i.e. 10 % in the affected length) and this was in the form of random loss of individual stones. Other examples of ravelling from single seals are given in Figures 29 to 31.

NOTE: The significance of ravelling lies in the loss of the integrity of the surfacing which results in a loss of imperviousness, potholes, etc.

TABLE V*Degrees of ravelling for various types of surfacing*

	SINGLE SEALS & SLURRY SEALS	MULTIPLE SEALS	ASPHALT SURFACING
Degree 1	No discernible loss of stone or slurry	No discernible loss of stone	No discernible loss of stone
Degree 2	No discernible loss of stone or slurry but assessed hardening (dryness) of binder	No discernible loss of stone but assessed hardening (dryness) of binder	Up to 2 mm disintegration (first sign fine stones lost, surface has pitted appearance)
Degree 3	No definition applies	Loss of stones from the top layer of a triple seal	2 to 7 mm disintegration (loss of intermediate sized stones)
Degree 4	No definition applies	Loss of second layer of triple seal or top layer of double seal	7 to 12 mm disintegration (loss of intermediate sized stones)
Degree 5	Loss of stone or slurry	Loss of stone from all layers	>12 mm disintegration (loss of all size stones)

In many cases, however, ravelling may occur without any serious consequences. Examples are:

- The loss of the top layer of a triple seal leaving behind an impervious and durable double seal because of a fault in the application of the top layer alone.
- The loss of some stone from a single surface treatment over an asphalt surfacing (because, for example, of insufficient precoat-ing) retaining an impervious surface with adequate skid resistance.
- Some ravelling of single seal on a lightly trafficked road soon after construction because of poor binder application in places, but where the condition has subsequently proved to be stable.

In view of this it is usually important to identify the cause, mechanism and probable consequences of ravelling when assessing its severity. Furthermore, if such conditions are anticipated, it is permissible to arrange to rate the degree of distress lower than would follow from the descriptions above, in line with the definitions given in Table IV. In any event, special annotations should be supplied whenever these conditions arise.

A.4.3.2 Potholes and edge breaks

Potholes are the cylindrical holes found in pavements. Edge breaks are the result of the breaking away of the asphalt surfacing at the end of the road. Note that it is not usual to refer to the loss of a surface seal in a circular area as a pothole if the underlying layer has not been affected.

If necessary the degree of potholing can be expressed by the diameter of the potholes and the degree of edge breaks by the distance from the edge of the pavement at which breaking has occurred. The classes of degree are:

- Degree 1 - no clear development of potholes (or edge breaks)
- Degree 2 - potholes <50 mm
- Degree 3 - potholes between 50 mm and 150 mm
- Degree 4 - potholes between 150 mm and 300 mm
- Degree 5 - potholes greater than 300 mm

The extent of potholes would normally be given by the "number" attribute. For edge breaks the extent would normally be given by the "length" attribute. Examples of potholes and edge breaks are given in Figures 32 and 33.

A.4.3.3 Patches

Areas from which surfacing material has been lost are often reinstated by patching. Although such patches are not strictly a type of distress, they do give an indication of the condition of the pavement in so far as it shows the extent of previous distress. Accordingly the spacing of patches is their average length and the extent and position are given in terms of the usual parameters. Alternatively, the number and average area of patches may be determined for a length of road.

A.4.4 Smoothing of the surface

Smoothing of the surface texture involves the loss of the macrotexture and/or microtexture of the surface (see Section 2.2) with a resultant loss in skid resistance. The two most common manifestations of this mode of distress are bleeding and polishing.

A.4.4.1 Bleeding

Bleeding occurs when the binder moves upwards relative to the aggregate at the surface of the pavement thus reducing surface texture depth (see Section

2.2). The measurement of this form of distress is complicated by the very different textures obtained in the different forms of newly laid surfacings (e.g. single surface treatments, multiple-surface treatments, dense-graded asphalt, gap-graded asphalt with precoated chips etc.). A common scale for the degree of bleeding for all types is, however, desirable, and the following scale is defined with a view to the distress as it affects skid resistance:

TEXTURE DEPTH		VISUAL APPEARANCE
Degree 1	above 1,0 mm	stones well proud of binder, >4 mm depth between stones
Degree 2	0,6 to 1,0 mm	rough texture but with shallow depths (2-4 mm) between stones
Degree 3	0,3 to 0,6 mm	smooth appearance with asperities >2 mm
Degree 4	0,0 to 0,3 mm	smooth appearance to the edge but stones visible in the binder
Degree 5	0,0	film of binder covering all stones

Degree 1 represents a texture depth that would be considered adequate for skid resistance of roads carrying high speed traffic whereas Degree 5 indicates the worst possible condition for skid resistance for all roads.

These descriptions of visual appearance relate to surface seals. A dense-graded asphalt for example, cannot attain a condition described as Degree 1 (and possibly Degree 2) even if there is no distress. It is also difficult to determine to what extent a lack of texture in depth is due to actual distress (i.e. a deterioration) rather than to the way it was constructed. Usually, however, only Degree 3 to Degree 5 is of practical interest. (In more detailed investigations though, it might be more suitable to give the texture depths directly, which is measure of the serviceability (see Section 2), rather than to indicate the amount of distress.)

The spacing of bleeding is the average length of areas of bleeding of at least a given degree.

Mechanisms of bleeding can be the reorientation of the aggregate, the embedment of the aggregate into the underlying material, etc.

Examples of bleeding surfaces are given in Figures 34 and 35.

A.4.4.2 Polishing

Polishing is the wearing smooth of the stones on the surface of the road (i.e. reduction of microtexture) with a concomitant reduction in skid resistance. The degree of polishing can be estimated by the pendulum tester (see Section 2.2(c)). The classes of the degree of polishing are defined as:

Degree 1 – greater than 75* (stones very harsh** , edges sharp to the touch)
Degree 2 – 75 to 55
Degree 3 – 55 to 45 (stones sharp and angular but not harsh)
Degree 4 – 45 to 35
Degree 5 – below 35 (stones rounded and smooth to the touch)

Figure 36 gives an example of surfacings with various degrees of polishing.

A.5 SUMMARY OF DEGREES OF DISTRESS

Table VI gives a summary of the classes of the degree of distress for the various types of distress.

*These figures are expressed in units of the pendulum tester.

**Harsh stones have surfaces that are rough to the touch.

TABLE VI
Summary of definitions of degrees of distress

DEGREE OF DISTRESS	MODE OF DISTRESS									
	DEFORMATION (AS MEASURED UNDER 2 M STRAIGHT-EDGE)	CRACKING	DISINTEGRATION OF SURFACING				SMOOTHING OF SURFACE			
			RAVELLING		POTHOLES AND EDGE BREAKS	TEXTURE DEPTH	BLEEDING APPEARANCE	PENDULUM VALUE	APPEARANCE	
			SINGLE SEALS AND SLURRY SEALS	MULTIPLE SEALS	ASPHALT SURFACING					
1	Less than 5 mm	Not visibly cracked	No discernible loss of stone or slurry	No discernible loss of stone	No discernible loss of stone	No clear development of potholes or edge breaks	>1,0 mm	Stones well proud of binder >4 mm depth between stones	>75	Stones very harsh, edges sharp to touch
2	5 to 10 mm	Faint cracks	No discernible loss of stone or slurry but assessed hardening (dryness) of binder	No discernible loss of stone but assessed hardening (dryness) of binder	Up to 2 mm disintegration (first sign of fine stones lost, surface has pitted appearance)	Width <50 mm	0,6 to 1,0 mm	Rough texture but with shallow depths (2-4 mm) between stones	55 to 75	
3	10 to 20 mm	Distinct cracks	No definition applies	Loss of stones from the top layer of a triple seal	2 to 7 mm disintegration (loss of intermediate sized stones)	Width 50 to 150 mm	0,3 to 0,6 mm	Smooth appearance with asperities >2 mm	45 to 55	Stones sharp and angular but not harsh
4	20 to 40 mm	Open cracks width <3 mm	No definition applies	Loss of second layer of triple seal or top layer of double seal	7 to 12 mm disintegration (loss of intermediate sized stones)	Width 150 to 300 mm	0,0 to 0,3 mm	Smooth appearance with no asperities but stones visible in the binder	35 to 45	
5	Greater than 40 mm	Open cracks width >3 mm	Loss of stone or slurry	Loss of stone from all layers	>12 mm disintegration, (loss of all size stones)	Width greater than 300 mm	0,0 mm	Film of binder covering all stones	<35	Stones rounded and smooth to touch

AD HOC PAVEMENT DESCRIPTIONS

B.1 INTRODUCTION

It is generally impossible to give a detailed description of the pavement condition for all sections of road since this would be exorbitantly costly and time-consuming. Careful thought must be given as to exactly what details are necessary and economically justified for a particular study. On the basis of this explicit instructions for the survey should be given, usually with suitable rating forms. But it is important to note that, irrespective of the purpose or detail of the inspection, it is essential that the terms and units of description should not be changed, so that any reader can immediately interpret the report.

In this Appendix three examples are given of reporting pavement condition to illustrate:

- (a) how the terms and units defined in this document are applied in practice; and
- (b) how the purpose and scope of a survey may vary.

B.2 EXAMPLES

B.2.1 Detailed description of distress

In some cases it may be necessary for an engineer to have a detailed description of the distress of a small section of pavement. Such a case may arise when he has to make a recommendation as to some corrective measure without being able to visit the site. An example of such a description* is:

"Cracking*¹ of the premix surfacing*² and pumping*³ of fines from the subbase*². Longitudinal*⁴ and transverse*⁴ cracking of Degree 4 at 3 m spacing over 50 per cent of the area*⁵; crocodile*⁴ cracking of Degree 3 at 100 to 300 mm spacing over 40 per cent of the area*⁵. The longitudinal and transverse cracking probably originated from shrinkage due to cement stabilization*⁶ of base*², aggravated by the settlement of a high fill*⁶, and the subsequent crocodile cracking to fatigue*³ under traffic, worsened by the presence of the shrinkage cracks and ingress of rainwater*⁶."

*Such a description will include those attributes of the distress that are relevant and are possible to obtain from a visual inspection. These are given in the example and are indicated in the following:

*¹ – mode of distress

*² – pavement component

*³ – mechanism

*⁴ – type of distress

*⁵ – degree, spacing, extent

*⁶ – cause

B.2.2 Pavement condition survey of a road network

Surveys of roads that may require maintenance are often made by road authorities in order to establish the maintenance requirements and priorities. Form 1 is a fairly detailed form that may be used in order to record the results of the inspection in a formal way. The assumption in preparing this form is that the only form of instrument that may be involved would be the occasional use of the dynamic cone penetrometer.

Information from these forms can be used to:

- (a) make a comparative analysis among roads needing maintenance in order to determine priorities;
- (b) review the recommendations of the field assessors by other experts or by a model designed to associate the various factors;
- (c) keep a record of the current condition as additional information for future surveys.

Examples of such inspection sheets abound in the literature. Each road authority must decide for itself which details will suit its purpose best in the light of its policy and attitude towards pavement maintenance. An important guide in designing these forms is a clear stipulation of how this information will be used.

B.2.3 Pavement management systems

Various pavement management systems are being developed in South Africa in which details of the pavement are computerized for storage and analysis. These data are primarily used for assessing maintenance requirements, for planning future expenditure and for guiding the policy of the authorities regarding pavement design and maintenance.

The data for such systems usually comes from several sources, for example:

- mechanical surveillance instruments such as the PCA road meter, SCRIM, etc.;
- visual assessments from district staff;
- traffic counts; and
- records of the pavement structure and past maintenance.

Records of the condition of the pavements in the road network are updated regularly. This involves a great deal of data and requires rapid means of data collection to be practicable. For visual assessments this means that the amount of detail to be recorded should be kept to a minimum. Also the fact that much of the data collection is decentralized and to a large extent depersonalized and because much of the processing is automated, means that the accuracy and standardization of reporting is of crucial importance.

A typical example of a visual assessment form for a pavement management system is given in Form 2. Such forms would generally be accompanied by a de-

tailed explanatory guide. Although the exact nature of these forms will depend on the pavement management system developed for the particular road authority, this form demonstrates the general principle that only the most essential aspects of the condition are recorded in this type of survey.

PAVEMENT CONDITION ASSESSMENT FORM

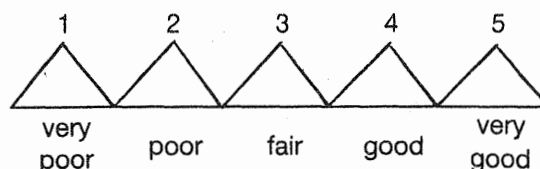
Rater(s) Date

Location: Road No. km to km

Traffic: Assessment vehicles/day

Functional features

Riding quality (subjective assessment)



Average texture depth

ROUGH	ADEQUATE	SMOOTH
-------	----------	--------

Surface drainage

ADEQUATE	UNCERTAIN	POOR
----------	-----------	------

Structural indicators

Type of surfacing

Drainage (comment)

DCP (comment)
(attach measurements)

Distress:

1. Cracking $\geq$ Degree 3

TYPE	EXTENT (LENGTH)	SPACING (m)	POSITION

2. Disintegration of surfacing:

Ravelling $\geq$ Degree 4 % Area % Length

Qualifying comment

Patches Number spacing (or % Length)

3. Smoothing of surfacing:

Bleeding $\geq$ Degree 4 % Length

Polishing Degree 5 % Length

4. Number of depressions or displacements along edge of pavement

ASSESSMENT

Urgency of maintenance

URGENT	NECESSARY	DESIRABLE	UNNECESSARY
--------	-----------	-----------	-------------

Type of maintenance required:

Reasons for assessment:

FORM 1

Pavement Condition Assessment Form

VISUAL INSPECTION FORM

VISUAL INSPECTION DATE

REGION

LOCATION			CRACKS ¹ ≥ DEGREE 3		PATCHES ² % LENGTH	BLEEDING ³ ≥ DEGREE 4 % LENGTH	SEVERITY OF LOSS OF STONE ⁴
ROAD NO.	FROM (KM)	TO (KM)	% LENGTH	AVERAGE SPACING			

Explanatory notes:

1. Only cracks in the riding surface of the road are considered, i.e. cracks in the shoulders are ignored.
2. Only patches along lengths of road not cracked are considered. This means that:
% length cracks + % length patches ≤ 100.
3. Only bleeding in the wheel paths is considered.
4. The severity of the loss of stone is recorded according to a procedure set out in the accompanying guide. This takes into account the degree and extent of the loss of stone. Photographs are supplied to assist the inspector in recognizing the various cases.

FORM 2

Example of a visual inspection form for a pavement management system

GLOSSARY

The numbers in parentheses are the numbers of the sections in which the terms are introduced.

Amorphous (multiple) cracks	Type of distress* of the mode "cracking" (A.4.2.1(ii))
Area of distress	A measure of the extent of distress (percentage of area affected) (A.2(c))
Attributes of distress	The various aspects taken into account when describing distress (A.2)
Behaviour	The function of the condition of the pavement with time(3)
BFC	Brake-force coefficient – value of skid resistance obtained from the brake-force trailer (2.2(b))
Bleeding	Type of distress* of mode "smoothing of surface texture" (A.4.4.1)
Block cracks	A type of distress* of the mode "cracking" (A.4.2.1(c))
BPR roughometer	An instrument for assessing riding quality developed by the Bureau of Public Roads of the USA (2.1(c))
Brake-force trailer	An instrument for assessing skid resistance (2.2(b))
Cause of distress	An extraordinary condition or set of circumstances necessary for the occurrence of the distress (A.3.1)
Coefficient of friction	The ratio of the force of frictional resistance and the force normal to the contact plane at which the friction occurs (2.2)
Coefficients of skid resistance	Coefficients of friction obtained by instruments used to assess skid resistance under conditions similar to those experienced by skidding vehicles (2.2)
Component, pavement	One of the various layers comprising the pavement structure (A.3.2)
Corrugations	Type of distress* of the mode "deformation" (A.4.1.1(f))

*The types of distress are defined further, with the aid of photographs, in Appendix A.

Cracking	A mode of distress*: the manifestation of cracks at the surface of the pavement (A.2(b))
Critical state of distress	That level of distress at which it is the most economical to maintain the pavement (4)
Crocodile cracks	Type of distress* of the mode "cracking" (A.4.2.1(e))
Deflection	Vertical elastic displacement of pavement surface under a standard axle load (3(a))
Deformation	A mode of distress, the manifestation of unevenness of the surface profile (A.2(b))
Degree of distress	A measure of the state of the distress at a point on the pavement (A.2(c))
Delimitative properties	Properties of materials that specify the conditions under which they behave satisfactorily (3(b))
Depressions	Type of distress* of the mode "deformation" (A.4.1.1(a))
Disintegration of surfacing	Mode of distress, occurs when surfacing material is broken up and lost (A.2(b) and Table III)
Displacements	Type of distress* of the mode "deformation" (A.4.1.1(e))
Distress	The visible manifestation of the deterioration of the pavement with respect to either the serviceability or the structural capacity (1)
Drainage	A measure of the ability of the structure to drain free water from the pavement (3(d) and Table II)
Edge breaks	Type of distress* of the mode "disintegration of surfacing" (A.4.3.2)
Extent of distress	Proportion of the pavement section exhibiting this distress or the frequency of occurrence of the distress (A.2(c))
Functional description	Description of the condition of a road in terms of its ability to fulfil its functional requirements (1)
Functional evaluation	The assessment of the degree to which the pavement fulfils its functional requirements (1)
Functional features	Properties of the pavement that determine its serviceability (2)

*The types of distress are defined further, with the aid of photographs, in Appendix A.

Cracking	A mode of distress*: the manifestation of cracks at the surface of the pavement (A.2(b))
Critical state of distress	That level of distress at which it is the most economical to maintain the pavement (4)
Crocodile cracks	Type of distress* of the mode "cracking" (A.4.2.1(e))
Deflection	Vertical elastic displacement of pavement surface under a standard axle load (3(a))
Deformation	A mode of distress, the manifestation of unevenness of the surface profile (A.2(b))
Degree of distress	A measure of the state of the distress at a point on the pavement (A.2(c))
Delimitative properties	Properties of materials that specify the conditions under which they behave satisfactorily (3(b))
Depressions	Type of distress* of the mode "deformation" (A.4.1.1(a))
Disintegration of surfacing	Mode of distress, occurs when surfacing material is broken up and lost (A.2(b) and Table III)
Displacements	Type of distress* of the mode "deformation" (A.4.1.1(e))
Distress	The visible manifestation of the deterioration of the pavement with respect to either the serviceability or the structural capacity (1)
Drainage	A measure of the ability of the structure to drain free water from the pavement (3(d) and Table II)
Edge breaks	Type of distress* of the mode "disintegration of surfacing" (A.4.3.2)
Extent of distress	Proportion of the pavement section exhibiting this distress or the frequency of occurrence of the distress (A.2(c))
Functional description	Description of the condition of a road in terms of its ability to fulfil its functional requirements (1)
Functional evaluation	The assessment of the degree to which the pavement fulfils its functional requirements (1)
Functional features	Properties of the pavement that determine its serviceability (2)

*The types of distress are defined further, with the aid of photographs, in Appendix A.

Functional requirement	The requirements of a pavement from the point of view of the road user. These requirements are the comfort, safety and convenience that the pavement should provide in the transportation of vehicles (1)
LDI	Linear displacement integrator, an instrument for assessing riding quality (2.1(b))
Length of distress	A measure of the extent of distress (percentage of length affected) (A.2.(c))
Location of distress	Identification of the location of the section of pavement for which description of distress is given (A.2(a))
Longitudinal cracks	Type of distress* of the mode "cracking" (A.4.2.1(b))
Macrotexture	The height and separation of stones projecting from the surface of the road (2.2)
Map cracks	Type of distress* of the mode "cracking" (A.4.2.1(d))
Material properties	The response of various road building materials to stresses, strains and moisture (3(b))
Meandering cracks	Type of distress* of the mode "cracking" (A.4.2.1(h))
Mechanism of distress	The physical process by which the cause of the distress results in the distress (A.3.1)
Microtexture	The degree to which the stones on the surface of a pavement are harsh and angular or smooth and rounded (2.2)
Modes of distress	The four major classes of distress (A.2(b))
Mounds	Type of distress* of the mode "deformation" (A.4.1.1(b))
Number of distress	A measure of the extent of distress (number of occurrences) (A.2(c))
Parabolic cracks	Type of distress* of the mode "cracking" (A.4.2.1(f))
PCA roadmeter	Instrument for assessing riding quality, developed by the Portland Cement Association (2.1(a))
Pendulum tester	Instrument for assessing skid resistance (2.2(c))

*The types of distress are defined further, with the aid of photographs, in Appendix A.

Performance	The serviceability of the pavement as a function of time (2)
Polished stones	Stones that have become smooth through the friction of traffic (2.2)
Polishing	Type of distress* of mode "smoothing of surface texture" (A.4.4.2)
Position of distress	The lateral position of distress with respect to the surface of the road (A.2(d))
Potholes	Type of distress* of the mode "disintegration of surfacing" (A.4.3.2)
Primary distress	Initial type of distress (A.3.3)
PSV	Polished stone value – a measure of the resistance of stone to polishing (2.2)
Ravelling	Type of distress* of the mode "disintegration of surfacing" (A.4.3.1)
Ridges	Type of distress* of the mode "deformation" (A.4.1.1(d))
Riding quality	The general extent to which road users experience, through the medium of their vehicles, a ride that is smooth and comfortable or bumpy and thus unpleasant and perhaps dangerous (2.1)
Ruts	Type of distress* of the mode "deformation" (A.4.1.1(c))
SCRIM	Instrument for the assessment of skid resistance (2.2(a))
Secondary distress	Types of distress occurring after (particularly as a result of) primary distress (A.3.3)
Serviceability	A measure of the extent to which a particular pavement meets the requirements of the road user (2)
Severe state of distress	Level of distress greater than the critical state (4)
Severity of distress	A measure of the seriousness of the distress, especially in terms of the need for maintenance (A.3.5)
SFC	Sideways force coefficient – value of skid resistance obtained from SCRIM (2.2(a))

*The types of distress are defined further, with the aid of photographs, in Appendix A.

Skid resistance	The general ability of a particular road surface to prevent skidding of vehicles (2.2)
Smoothing of surface texture	Mode of distress, loss of macrotexture and/or microtexture (A.2(b))
Spacing	An attribute of distress pertaining to its geometry (A.2(d))
Star cracks	Type of distress* of the mode "cracking" (A.4.2.1(g))
Structural adequacy	Assessment of the adequacy of the structural capacity in relation to the prevailing traffic and environmental conditions (3)
Structural capacity	The ability of the pavement to withstand the effects of climate and traffic (3)
Structural description	An expression of properties of the pavement pertinent to a structural evaluation (1)
Structural distress	Distress pertaining to the load-bearing capacity of the pavement (A.3.4)
Structural evaluation	The assessment of the structural capacity of the pavement (1 and 3)
Structural indicators	Properties of the pavement pertinent to a structural evaluation (3)
Structural integrity	The soundness of the pavement seen as a system of interdependent components (3(c))
Structural reaction	The stresses and strains introduced in the pavement by loading on the surface (3(a))
Structural response	Response of the pavement (i.e. change in its behaviour) to some form of input to the pavement system (3(f))
Structural strength	An assessment of the strains that can be tolerated by the pavement in relation to those induced by a standard axle load under prevailing environmental conditions (3)
Surface distress	Distress pertaining to the wearing and skid resistance of the surfacing (A.3.4)
Surface drainage	The general ability of the road to keep its surface clear of water (2.3)
Surface texture depth	A measure of macrotexture established by the sand patch test (2.2)

*The types of distress are defined further, with the aid of photographs, in Appendix A.

Terminal condition	Predefined state of distress for terminating experimental observations (4)
Terminal level	A minimum acceptable level of some feature of the road in terms of its serviceability (2 and 4)
Transverse cracks	Type of distress* of the mode "cracking" (A.4.2.1(a))
Type of distress	The subclassification of the various manifestations of a particular mode of distress (A.2(b) and Table III)
Undulations	Type of distress* of the mode "deformation" (A.4.1.1(g))

*The types of distress are defined further, with the aid of photographs, in Appendix A.

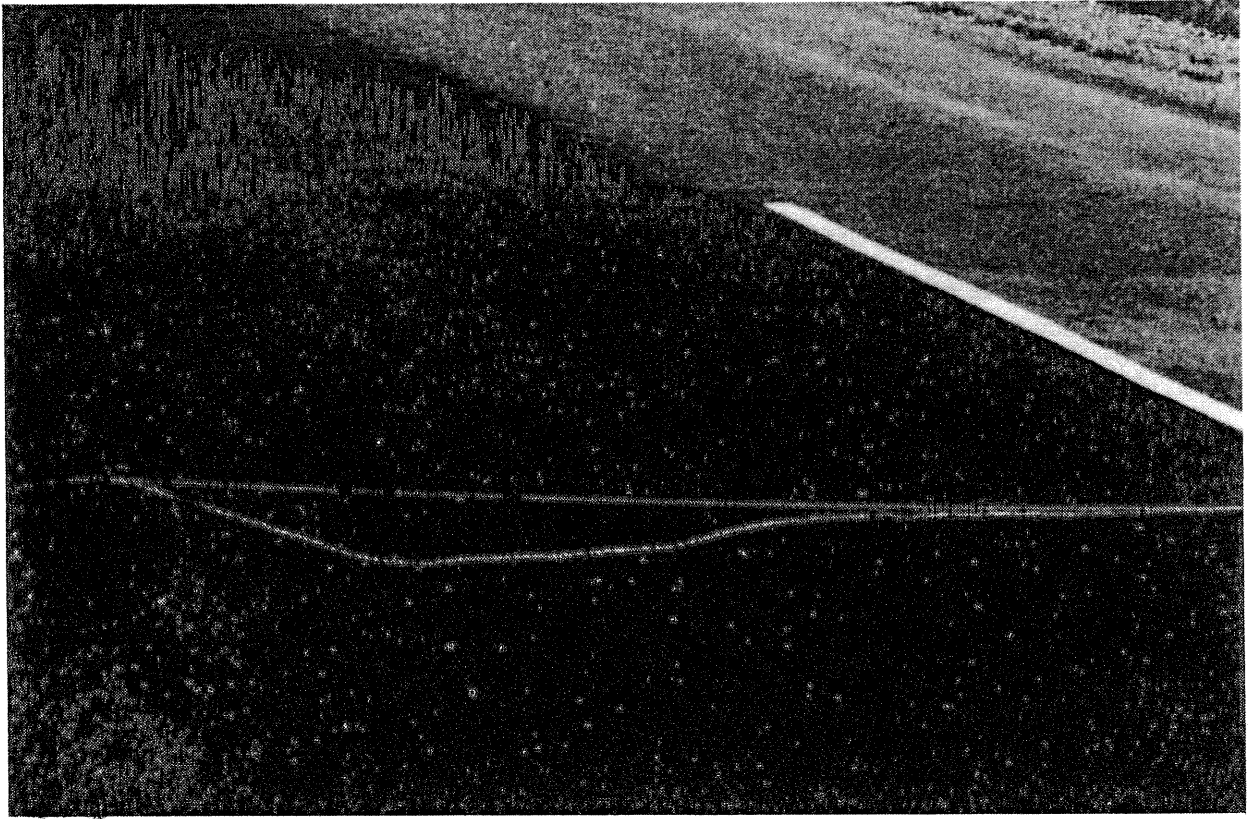


FIGURE 12

Distress : *Displacement, Degree 5 in outer wheel path*



FIGURE 13

Distress : *Depression on edge of pavement
(causing ponding of water)*

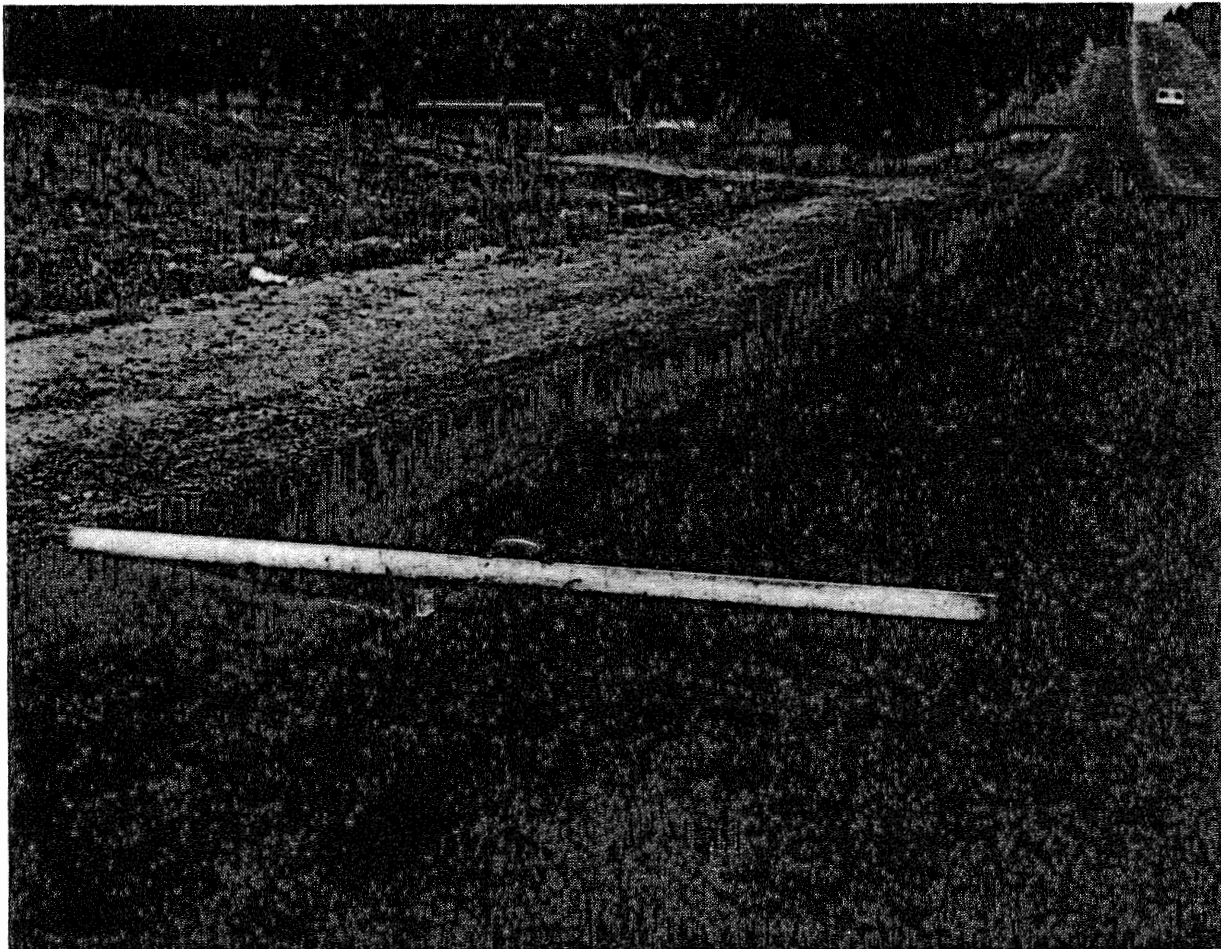


FIGURE 14

Distress : *Rut in outer wheel path, Degree 5*



FIGURE 15

Distress : *Transverse ridge*

Cause : *Active clay subgrade*

Mechanism : *Differential heaving of subgrade under culvert because of concentration of water and lesser weight of culvert*



FIGURE 16

Distress : *Corrugations, Degree 3 Length 5 Spacing 1 m*

Cause : *Unstable base material and tangential forces of traffic due to down grade of road*

Mechanism : *Shoving*

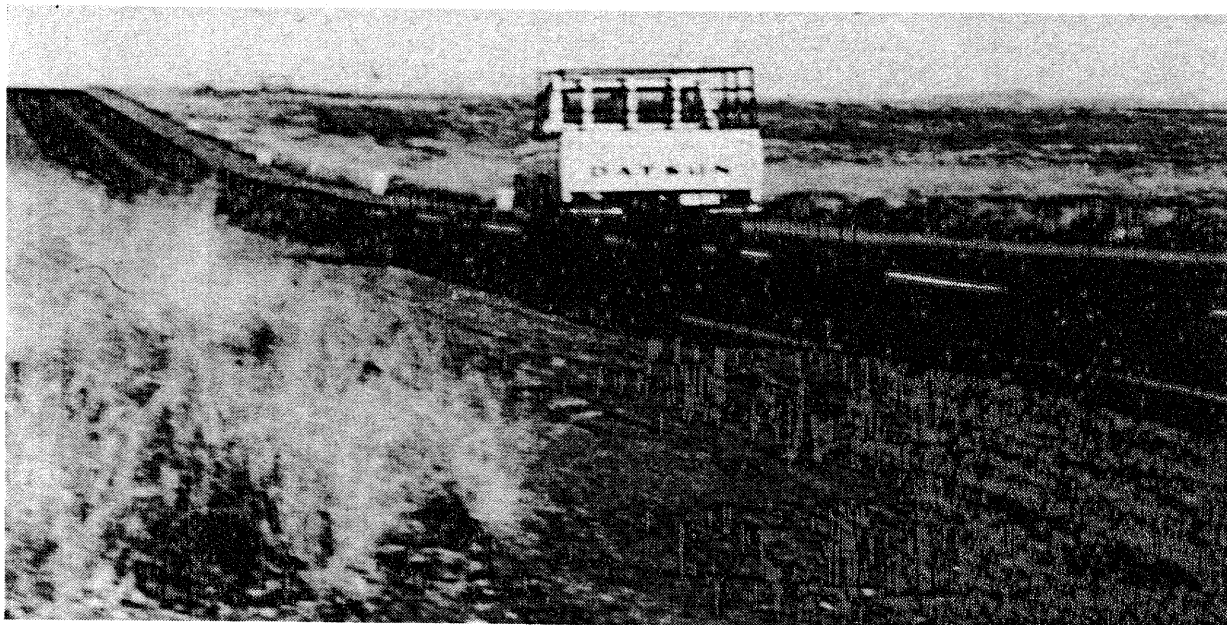


FIGURE 17

Distress : *Undulations*

Cause : *Active subgrade*

Mechanism : *Heave*

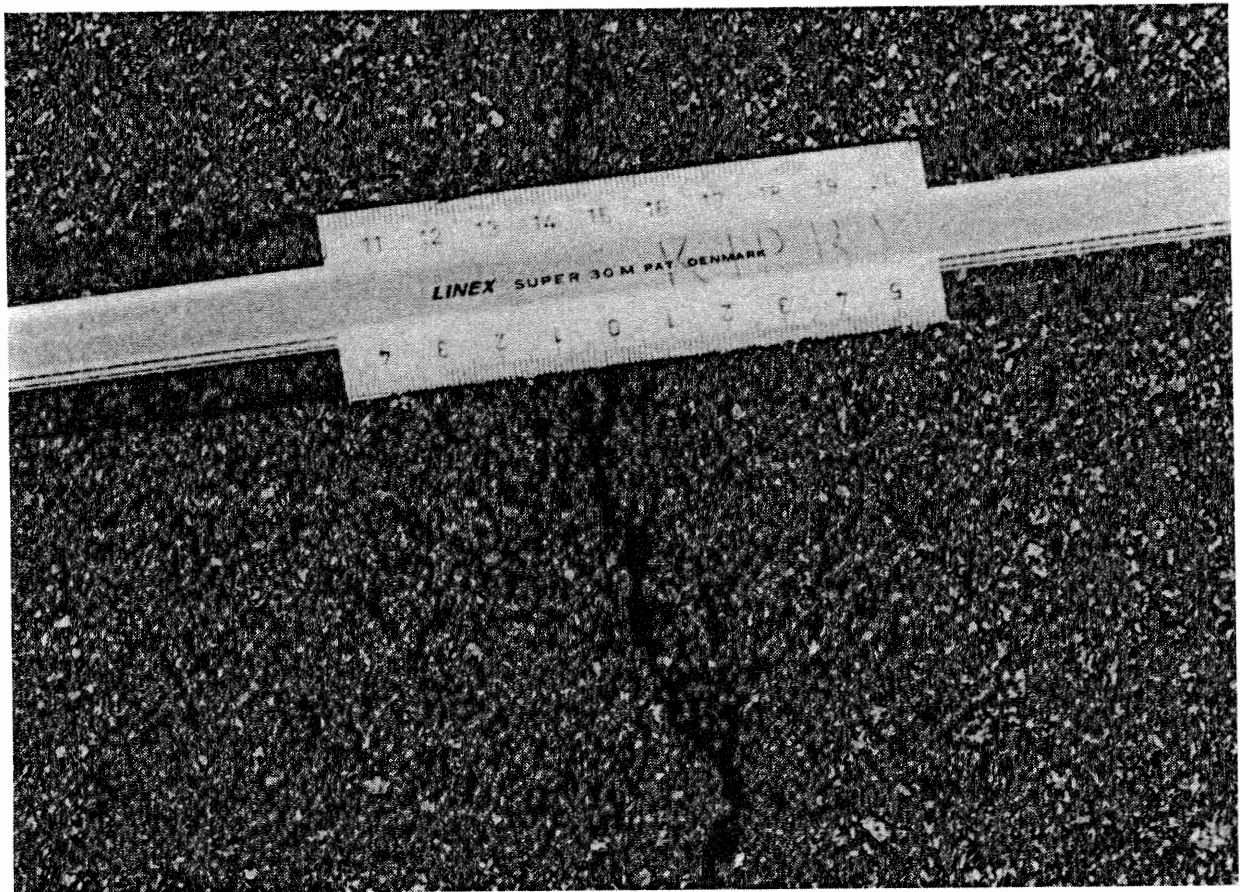


FIGURE 18

Distress : *Transverse crack, Degree 4*



FIGURE 19

Distress : *Transverse cracks, Degree 5 Spacing 1,8 m*



FIGURE 20

Distress : *Longitudinal crack, Degree 5*



FIGURE 21

Distress : Block cracks, Degree 5 Spacing 3 m

Cause : Shrinkage and cracking of stabilised base

Mechanism : Reflection of cracks through surface

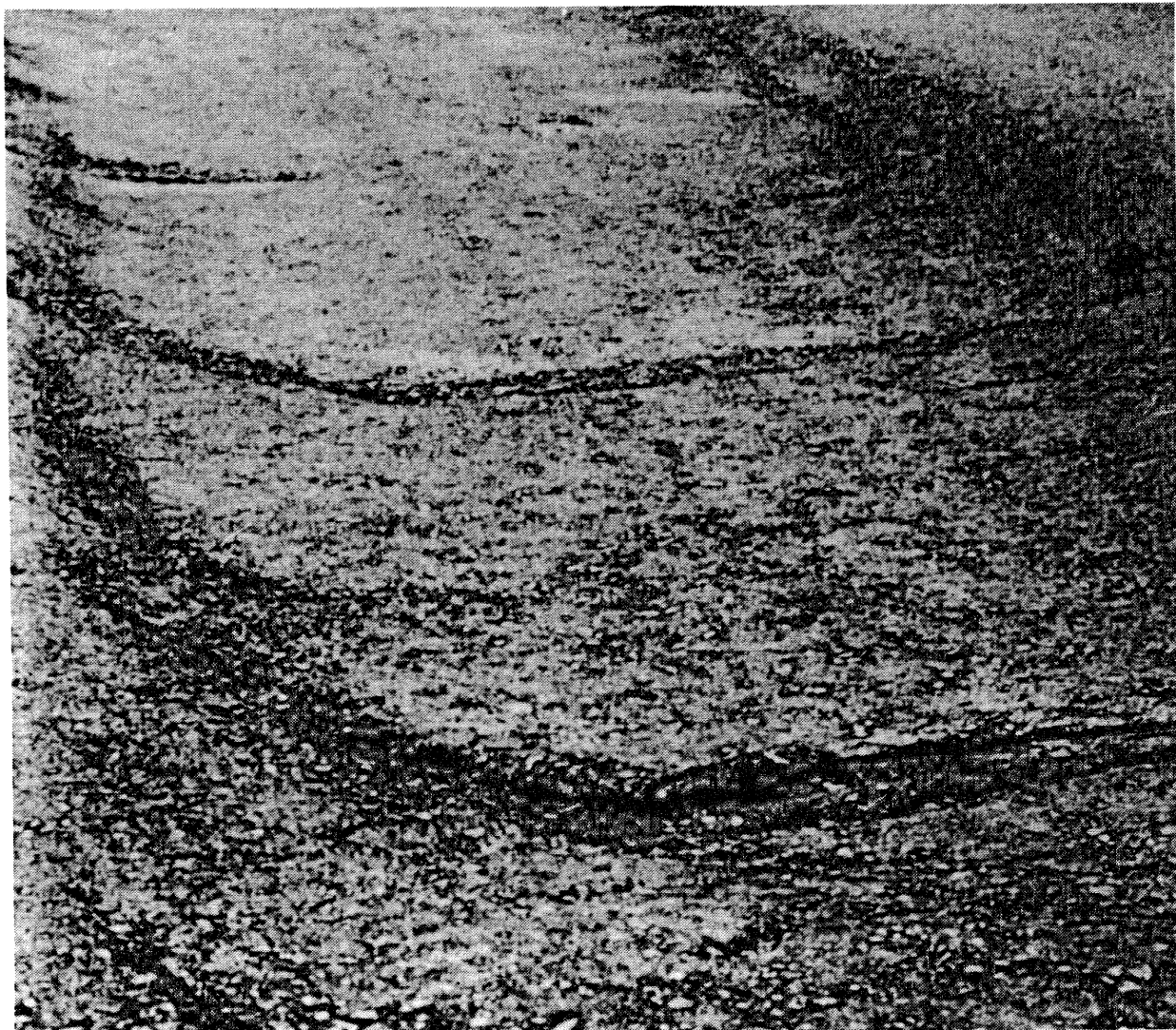


FIGURE 22

Distress : *Parabolic cracks, Degree 5*

Cause : *Poor bond between surfacing and base on steep upgrade*

Mechanism : *Shear at the interface of the base and surfacing*

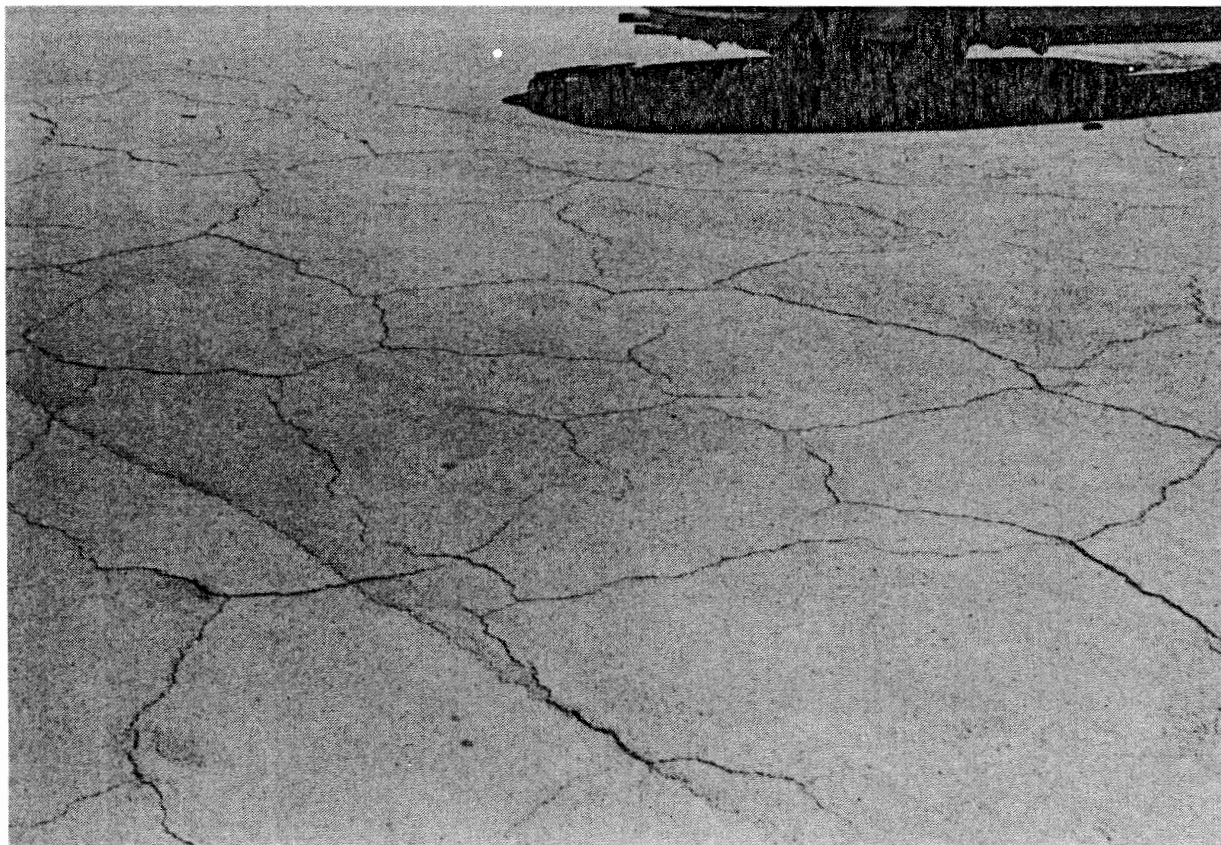


FIGURE 23

Distress : *Map cracks, Degree 4*

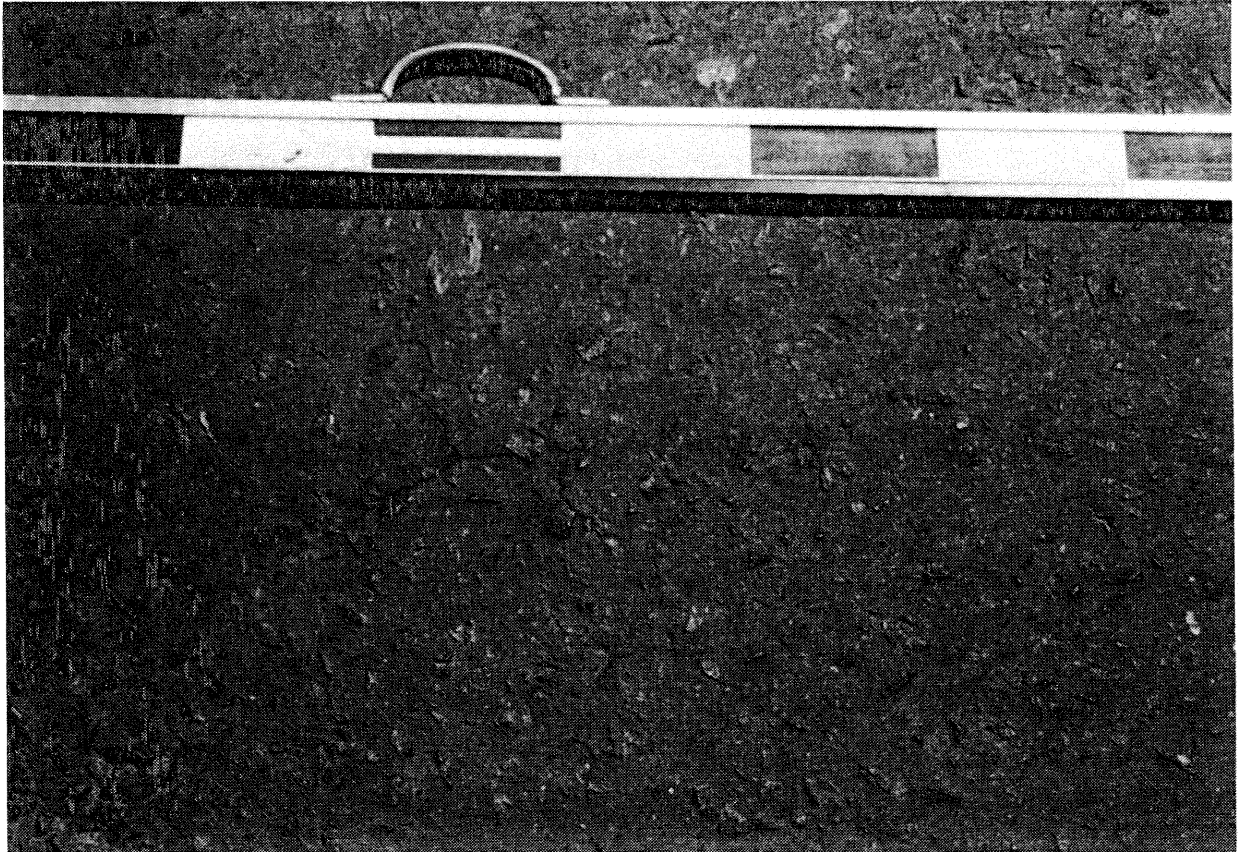


FIGURE 24

Distress : *Crocodile cracks, Degree 2*
(Straight-edge marked horizontally in decimeters)



FIGURE 25

Distress : *Crocodile cracks, Degree 3*

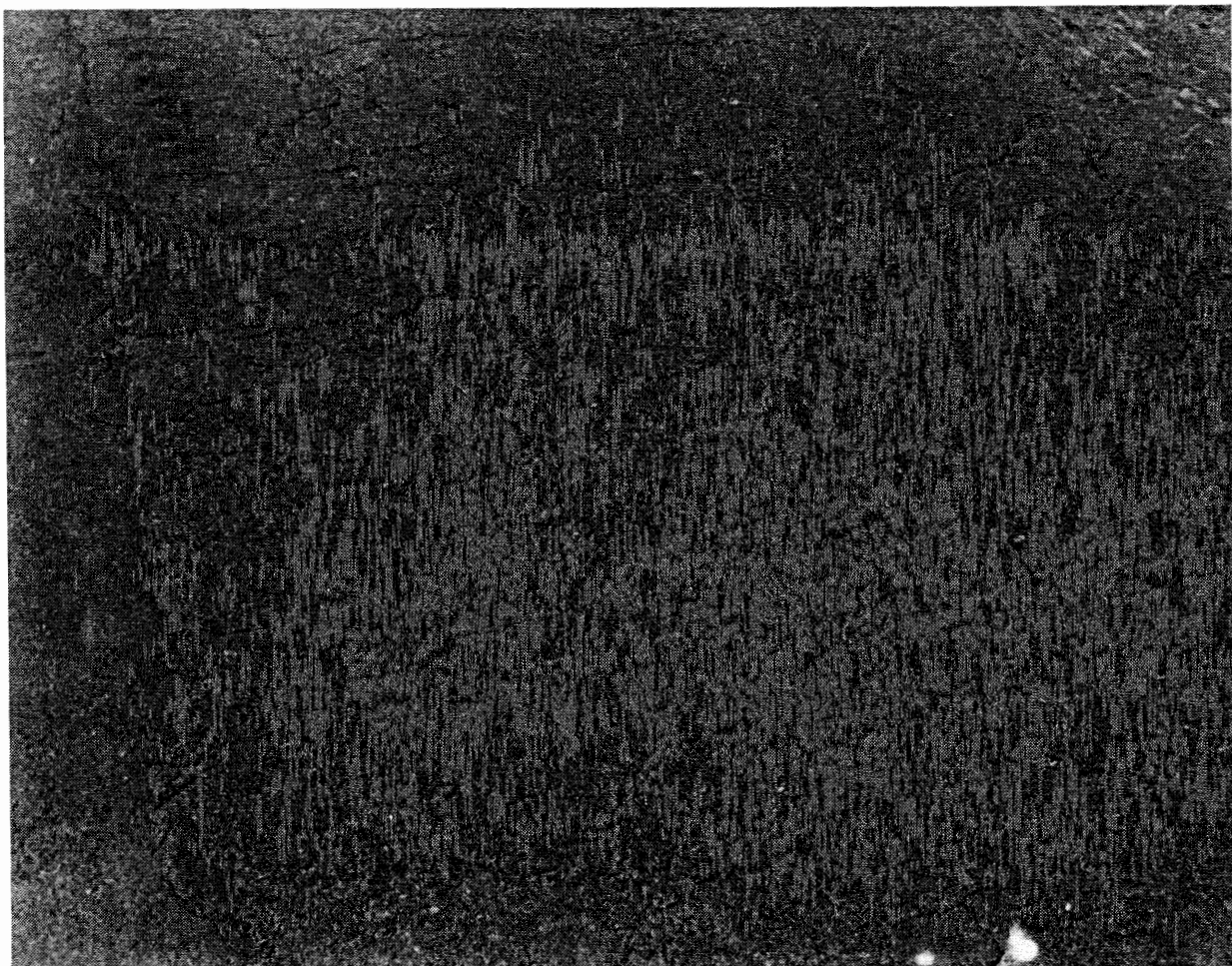


FIGURE 26

Distress : *Crocodile cracks, Degree 4*

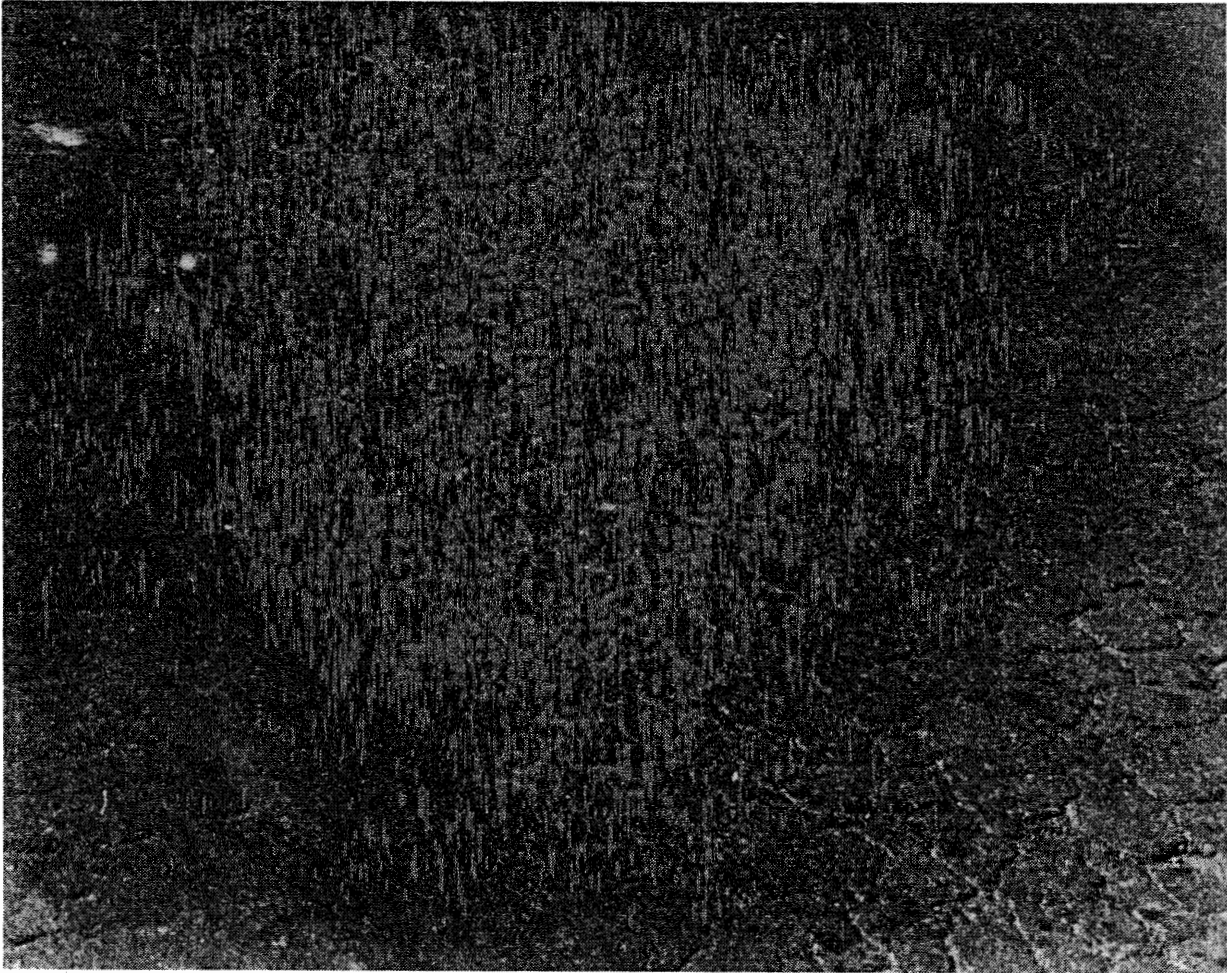


FIGURE 27

Distress : *Crocodile cracks, Degree 5*



FIGURE 28

- Distress** : *Amorphous cracks, Degree 5
Primary transverse cracking. Secondary block cracking followed by crocodile cracking*
- Cause** : *Hard (brittle) binder in surfacing*
- Mechanism** : *Shrinkage of surfacing*



FIGURE 29

Distress : *Ravelling, Degree 5 Spacing 5 mm*

Cause : *Quartzite aggregate contaminated by shale*



FIGURE 30

Distress : *Ravelling, Degree 5 Spacing 100 mm*

Cause : *Ageing of binder*



FIGURE 31

Distress : *Ravelling, Degree 5 Area 50 % Spacing 100 mm*

Cause : *Too hard a grade of binder used*

Mechanism : *Loss of adhesion*



FIGURE 32

Distress : *Pothole, Degree 5*

Cause : *Crocodile cracking of surfacing*



FIGURE 33

Distress : *Edge break, Degree 4*

Cause : *Salt action caused loss of density of shoulder and thus loss of material support for Cape seal*

Mechanism : *Shearing off of seal at edge of pavement*

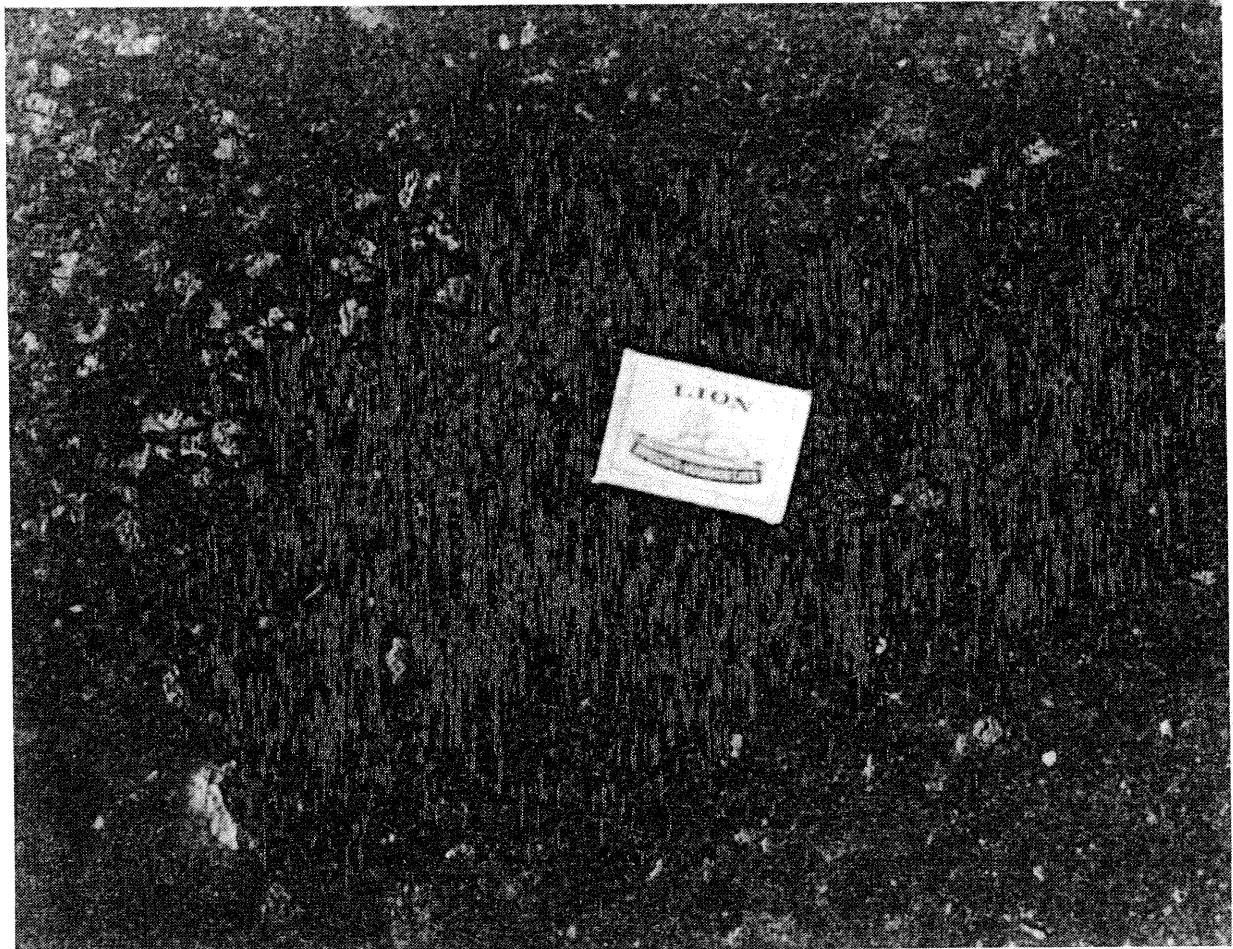


FIGURE 34

Distress : *Bleeding, Degree 4*

Cause : *Surfacing mix too rich*



FIGURE 35

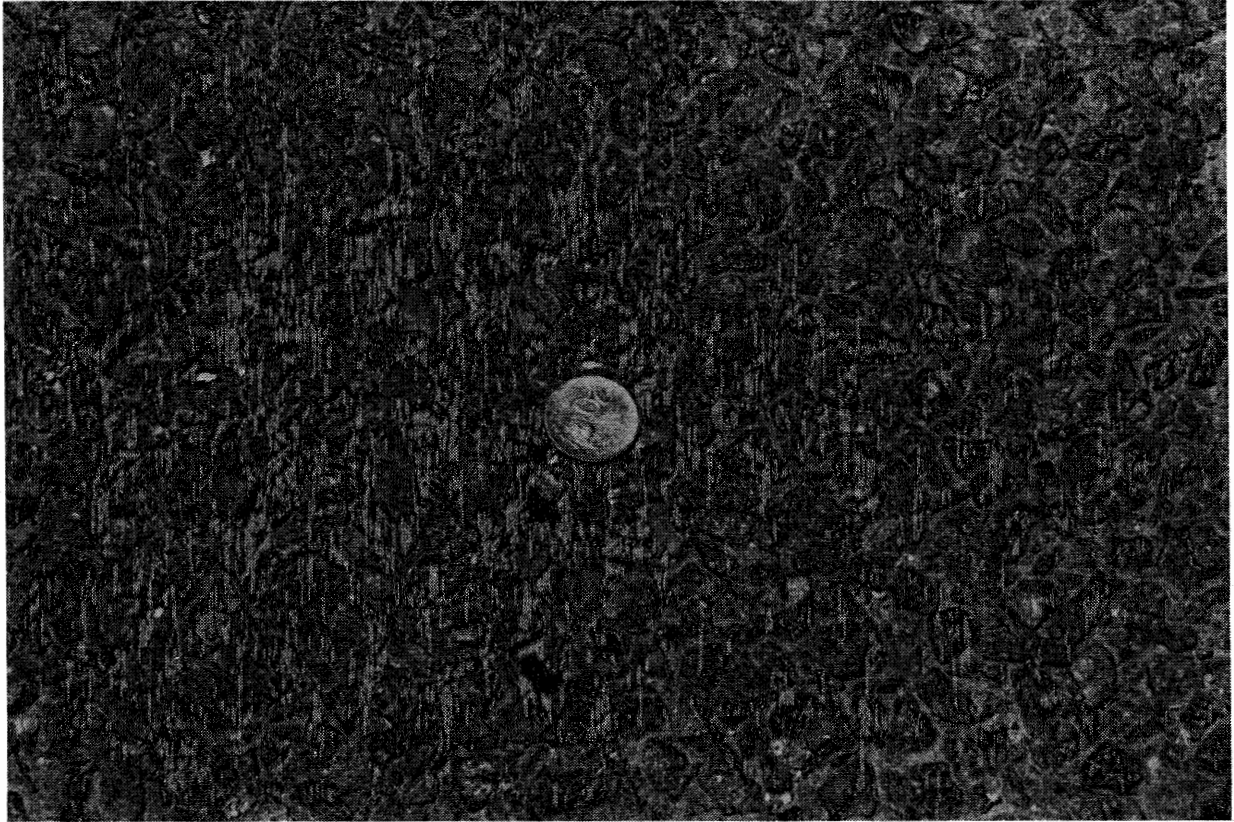
General view of the road in Figure 34



(a) Degree 1 Stones harsh to touch

FIGURE 36

An illustration of the different degrees of polishing



(b) Degree 3 Stones sharp and angular but not harsh

FIGURE 36 *(continued)*



(c) Degree 5 Stones rounded and smooth to touch

FIGURE 36 *(continued)*