South Africa

COTO

Committee of Transport Officials

TMH 9

MANUAL FOR VISUAL ASSESSMENT OF ROAD PAVEMENTS
PART D: BLOCK PAVEMENTS

Committee Draft Final

May 2016

Committee of Transport Officials

TECHNICAL METHODS
FOR HIGHWAYS

TMH 9

MANUAL FOR VISUAL ASSESSMENT OF ROAD PAVEMENTS

Part D: Block Pavements

Committee Draft Final

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Compiled under auspices of the:

Roads Coordinating Body (RCB)
Committee of Transport Officials (COTO)
Road Asset Management Systems (RAMS) Subcommittee

Published by:

The South African National Roads Agency SOC Limited
PO Box 415, Pretoria, 0001

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Synopsis

TMH 9 provides the procedures for the visual assessment of the condition of roads. Assessment procedures and requirements for road segment information data are specified. Different distress types are classified and detailed descriptions of degree of distress (including photographic plates illustrating condition) for each of the distress types are given. TMH 9 is a companion document to TMH 22 on Road Asset Management Systems.

Withdrawal of previous publication:

This publication replaces the previous Draft TMH9 “Standard Visual Assessment Manual for Flexible Pavements” published in 1992. This previous publication is effectively withdrawn with the publication of this document.

Technical Methods for Highways:

The Technical Methods for Highways consists of a series of publications in which methods are prescribed for use on various aspects related to highway engineering. The documents are primarily aimed at ensuring the use of uniform methods throughout South Africa, and use thereof is compulsory.

Users of the documents must ensure that the latest editions or versions of the document are used. When a document is referred to in other documents, the reference should be to the latest edition or version of the document.

Any comments on the document will be welcomed and should be forwarded to coto@nra.co.za for consideration in future revisions.

Document Versions

Working Draft (WD). When a COTO subcommittee identifies the need for the revision of existing, or the drafting of new Technical Recommendations for Highways (TRH) or Technical Methods for Highways (TMH) documents, a workgroup of experts is appointed by the COTO subcommittee to develop the document. This document is referred to as a Working Draft (WD). Successive working drafts may be generated, with the last being referred to as Working Draft Final (WDF). Working Drafts (WD) have no legal standing.

Committee Draft (CD). The Working Draft Final (WDF) document is converted to a Committee Draft (CD) and is submitted to the COTO subcommittee for consensus building and comments. Successive committee drafts may be generated during the process. When approved by the subcommittee, the document is submitted to the Roads Coordinating Body (RCB) members for further consensus building and comments. Additional committee drafts may be generated, with the last being referred to as Committee Draft Final (CDF). Committee Drafts (CD) have no legal standing.

Draft Standard (DS). The Committee Draft Final (CDF) document is converted to a Draft Standard (DS) and submitted by the Roads Coordinating Body (RCB) to COTO for approval as a draft standard. This Draft Standard is implemented in Industry for a period of two (2) years, during which written comments may be submitted to the COTO subcommittee. Draft Standards (DS) have full legal standing.

Final Standard (FS). After the two-year period, comments received are reviewed and where appropriate, incorporated by the COTO subcommittee. The document is converted to a Final Standard (FS) and submitted by the Roads Coordinating Body (RCB) to COTO for approval as a final standard. This Final Standard is implemented in industry for a period of five (5) years, after which it may again be reviewed. Final Standards (FS) have full legal standing.

Table of Contents

ITEM **PAGE**

D.1. Introduction D-1
D.2. General information D-2
D.2.1. Block shape D-2
D.2.2. Lay pattern D-2
D.2.3. Block thickness D-3
D.2.4. Chamfers D-4
D.3. Engineering assessment D-5
D.3.1. General D-5
D.3.2. Spalled/ cracked/ broken blocks D-5
D.3.3. Block surface integrity D-7
D.3.4. Loss of jointing sand D-9
D.3.5. Edge restraints D-11
D.3.6. Rutting D-13
D.3.7. Potholes / patching / reinstatements D-15
D.3.8. Undulations / shoving D-17
D.4. Functional Assessment D-19
D.4.1. Roughness D-19
D.4.2. Skid Resistance D-20
D.4.3. Surface Drainage D-20
D.4.4. Shoulders D-21
D.5. Summary D-22
D.5.1. Overall condition of pavement D-22
D.5.2. Comments and other problems D-22
D.6. Assessment form D-23

List of Figures

FIGURE **PAGE**

Figure D.1: Illustration of paving block shapes D-2
Figure D.2: Illustration of lay patterns D-3
Figure D.3: Pumping adjacent to edge restraint as a result of poor drainage D-11
Figure D.4: Noticeable trench reinstatement on a block pavement D-15

List of Tables

TABLE **PAGE**

Table D.1: Definition of block shape codes D-2
Table D.2: Description of lay pattern codes D-3
Table D.3: Description of chamfer codes D-4
Table D.4: Description of degree of spalled/ cracked/ broken blocks D-5
Table D.5: Description of block surface integrity D-7
Table D.6: Description of degrees of loss of jointing sand D-9
Table D.7: Description of degrees of edge restraint or anchor beam damage D-11
Table D.8: Description of degrees of rutting D-13
Table D.9: Description of degrees of potholes / patching / reinstatements D-15
Table D.10: Description of degrees of undulations / shoving D-17
Table D.11: Description of Degrees of Roughness D-19
Table D.12: Description of Degrees of Skid Resistance D-20
Table D.13: Description of Degrees of Surface Drainage Ratings D-20
Table D.14: Description of degrees of unpaved shoulder conditions D-21
Table D.15: Description of Degrees of Overall Condition of Pavement D-22

PART D. BLOCK PAVEMENTS

Note: Examples and actual dimensions presented in this Part are given as guidelines only and should not be regarded as fixed rules.

D.1. Introduction

This Part of the manual provides guidelines for the visual condition assessment of segmented block pavements. Segmented block pavements include brick and cement pavers and cobble stones.

The segment length that is evaluated is the same as for concrete pavements and is a length of 200 m in rural situations, and street "block" length in urban areas. The items required for the visual assessment of block pavements are listed as follows:

- General Information
  - Block shape and type
  - Lay pattern
  - Block thickness
  - Chamfers
- Engineering assessment
  - Spalled/ cracked/ broken blocks
  - Block surface integrity (durability)
  - Loss of jointing sand- resulting in loose blocks/ pumping/ differential block levels
  - Edge restraints
  - Rutting
  - Potholes/ patching/ reinstatements
  - Undulations/ shoving
- Functional assessment
  - Roughness (Riding quality)
  - Skid resistance
  - Drainage
    - Surface
    - Side
  - Shoulders
    - Paved
    - Unpaved
  - Edge condition

D.2. General information

This section covers the evaluation of the segmented block characteristics and lay pattern of the surface.

D.2.1. Block shape

The block pavers shape code is based on the degree of interlock that can be achieved between vertical faces of adjacent blocks, and is given in Table D.1, and illustrated in Figure D.1.

Table D.1: Definition of block shape codes

Code	Description
S-A	Blocks which allow geometrical interlock between **ALL** vertical faces of adjacent blocks.
S-B	Blocks which allow geometrical interlock between some faces of adjacent blocks.
S-C	Blocks which allow no geometrical interlock between adjacent faces.

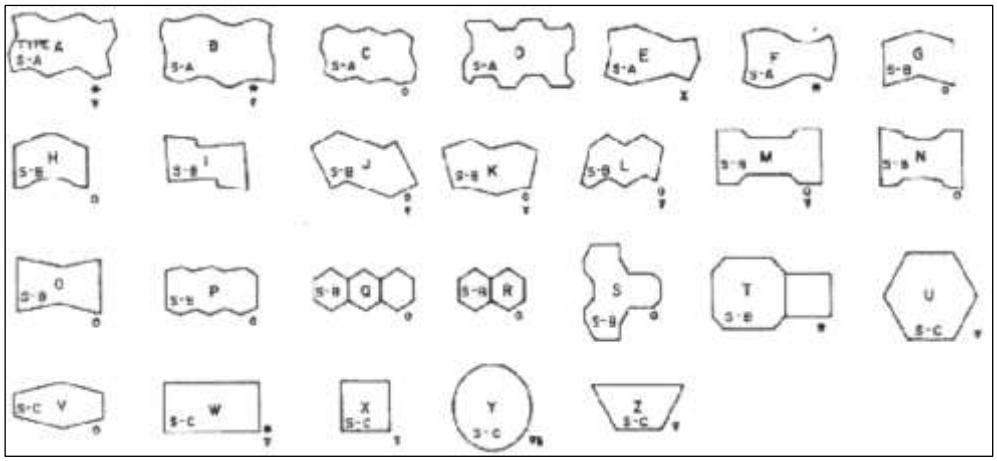


Figure D.1: Illustration of paving block shapes

D.2.2. Lay pattern

Block lay patterns are determined by performance and aesthetic requirements. The three patterns shown in Figure D.2 are the basic patterns. The pattern code (Table D.2) must be recorded on the visual assessment form. Numerous other patterns are also possible. Permeable paving, where the pavement structure is designed to allow entry of water into the pavement structure would be classified as OT (other). The herringbone pattern ensures the best resistance to both horizontal and vertical forces and is generally recommended for industrial and trafficked pavements.

Table D.2: Description of lay pattern codes

Code	Description
HB	Herring-bone
SB	Stretcher-bond
BW	Basket Weave
OT	Other

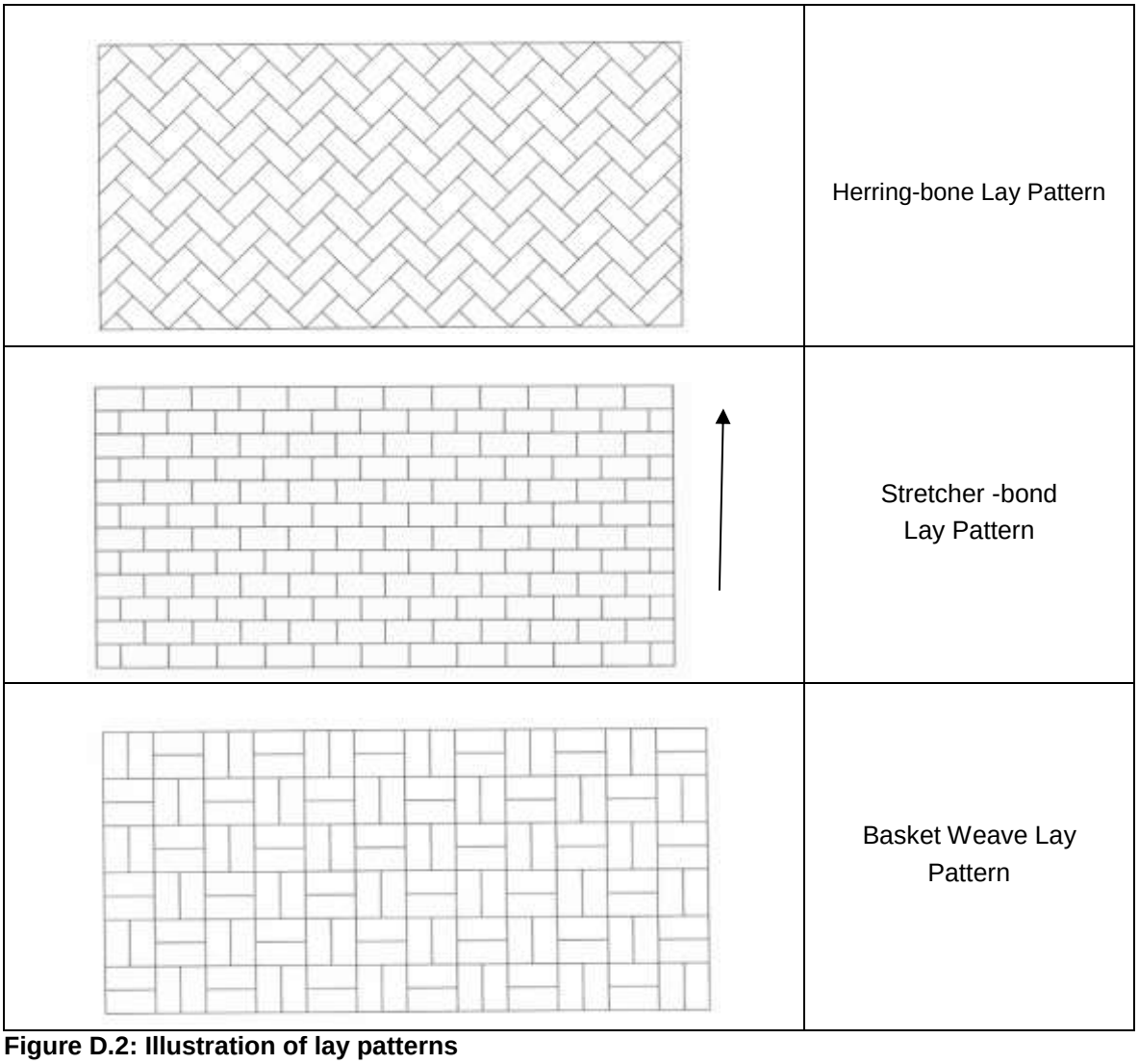


Figure D.2: Illustration of lay patterns

D.2.3. Block thickness

Concrete paving block thickness varies between 50 and 80mm. However brick or burnt clay blocks tend to be thicker. The thicker the blocks the better the pavement will resist vertical deformation and horizontal creep.

The visual assessor is required to estimate the block thickness unless it is possible to physically measure it, e.g. at missing or loose blocks or at poorly constrained edges.

D.2.4. Chamfers

Chamfering the top edges of blocks improves their service performance and appearance. Paving block chamfer reduces stress concentration at the surface. The absence of a chamfer may result in accentuated spalling. Chamfers can either be at a 45° angle, rounded or 90° angle (i.e. none). The chamfer codes are given in Table D.3.

Table D.3: Description of chamfer codes

Code	Description
45	45° angle chamfer
R	Rounded chamfer
90	90° chamfer (i.e. none)

CHAMFERS	
	45 45° Angle chamfer
	R Rounded Chamfer

D.3. Engineering assessment

D.3.1. General

Assessment will follow the requirements for degree and extent as discussed in Part A (sections A.2.2. and A.2.3). Although only three degrees of distress are illustrated in this document (degree 1, 3 and 5), use should be made of degrees 2 and 4 where necessary. The definitions for these two categories are described in Part A, section A.2.2.

D.3.2. Spalled/ cracked/ broken blocks

Description

Spalled blocks have chips out of the edges on the surface, generally because of stress concentrations through blocks deforming too much or the joint between adjacent blocks is unfilled or too narrow. Spalling is generally a precursor to cracking. Cracked blocks refer to block pavers that are cracked, and when extensively cracked or shattered these would be termed broken.

Possible causes:

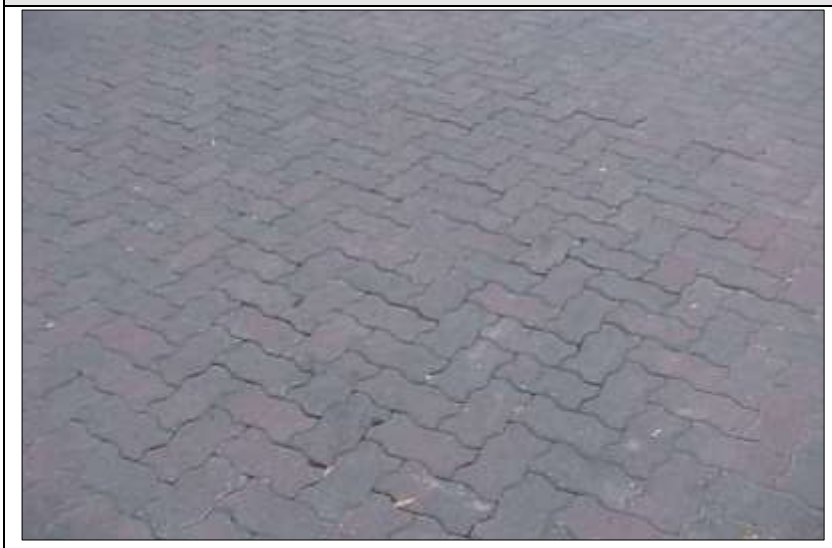
Possible causes of spalled or cracked blocks are:

- Insufficient structural support;
- Block strength - unlikely if blocks conform to SABS specifications;
- Too thick bedding layer;
- Coarse substrate or stones in bedding layer;
- Mechanical damage.

Table D.4: Description of degree of spalled/ cracked/ broken blocks

Degree	Description
1	Single cracks or chips per block with minimal spalling at cracks.
3	More than one crack or chip occurring on individual blocks, and spalling at cracks.
5	Shattered blocks losing parts of the blocks.

SPALLED / CRACKED / BROKEN BLOCKS



1

X	2	3	4	5

Single cracks or chips per block

3

1	2	X	4	5

More than one crack or chip per block

5

1	2	3	4	X

Shattered blocks

D.3.3. Block surface integrity

Under severe chemical and or mechanical conditions the upper surface of the blocks may wear away. Blocks are generally manufactured with a durable and wear resistant topping layer. When this layer starts to wear away it could affect the integrity of the blocks, and thus the structural capacity. The texture that is evaluated is not the same as on other pavement types where the texture is a reflection of the skid resistance. Generally the chamfers provide sufficient texture to drain surface water from the tyre/surface contact patch.

Table D.5: Description of block surface integrity

Degree	Description
1	Minimal evidence of wear visible.
3	Evidence of aggregate loss on surface, and some loss of the chamfer profile.
5	Rounding of the upper block surface as a result of severe aggregate loss.

BLOCK SURFACE INTEGRITY (DURABLITY)

1

X	2	3	4	5

Minimal evidence of wear

3

1	2	X	4	5

Some evidence of surface aggregate loss and chamfer wear

5

1	2	3	4	X

Rounding of upper surface of block through wear

D.3.4. Loss of jointing sand

Jointing sand in the joints assists with keeping water out of the pavement, and provides load transfer between adjacent blocks. The loss of jointing sand is probably one of the most common defects affecting block pavements. The loss of jointing sand could be the result of inadequate filling at the time of construction or loss of sand through the action of wind or water. The result of a loss of jointing sand is that water readily enters the pavement layers as the joints serve as water reservoirs and under the action of traffic the fine material in the bedding sand layer or even the subbase is pumped out. This leaves an uneven surface with steps between adjacent blocks. With the opening of the joints, the blocks move horizontally, increasing the joint size and allowing even more water to enter the pavement structure. In this condition the blocks are loose, and rattle when vehicles pass over the surface. The loss of jointing sand also reduces the load transfer between individual blocks and the pavement loses its integrity or “beam effect”.

The standard approach to overcome the loss of jointing sand is to regularly re-sand the joints during the maintenance period following construction at 3 monthly intervals. During routine operations the joints must be re-sanded when the sand is at a depth of 20 mm below the block surface, or degree 3 in Table D.6. When there is a sand loss of degree 5 the blocks have to be lifted and replaced, as routine maintenance joint filling will be ineffective.

The degree of distress for loss of jointing sand is given in Table D.6.

Table D.6: Description of degrees of loss of jointing sand

Degree	Description
1	The jointing sand is less than 10 mm below the surface of the blocks, and the block paving is integral and has achieved lock-up.
3	Jointing sand is more than 20 mm below the surface of the blocks. Paving blocks loose lock-up and joints widen with differential levels between blocks. Blocks move under loading and pumping occurs.
5	A limited amount of jointing sand present in the joints, joint widths are variable and the blocks can be rocked by standing on them. The levels of adjacent blocks are not even and pumping occurs.

LOSS OF JOINTING SAND

1

X	2	3	4	5

Jointing sand less than 10 mm below block surface

3

1	2	X	4	5

Jointing sand more than 20 mm below block surface. Blocks move.

5

1	2	3	4	X

Little jointing sand between blocks, which move and are not even. May pump.

D.3.5. Edge restraints

Edge restraints consist of kerbing, channels or other similar edge strips, or anchor beams on steep gradients to prevent downhill creep of the paving blocks. The objective of edge restraints is to prevent any lateral movement of pavers located along the edge of the pavement. This ensures that the overall integrity of the pavement is maintained. Edge restraints or anchor beams must not trap water, and should have drainage holes at the level of the bedding sand. Sections displaying lack of drainage show up as pumping adjacent to the edge restraint or beam, as shown in Figure D.3. The pavement defects would be listed under loss of jointing sand.

Figure D.3: Pumping adjacent to edge restraint as a result of poor drainage

Possible causes

Damage to edge restraints is often caused by heavy vehicle traffic, poor subgrade conditions or poor construction quality and materials.

Severity levels

In cases where edge restraints are missing, damaged or structurally inadequate to perform their function, this should be noted.

Table D.7: Description of degrees of edge restraint or anchor beam damage

Degree	Description
1	Cracks visible without obvious lateral displacement of restraint.
3	Severe cracking visible, lateral displacement of restraint present.
5	Edge restraint not functional – sections missing or severely displaced.

EDGE RESTRAINT OR ANCHOR BEAM DAMAGE

1

X	2	3	4	5

Cracking but no displacement. (Note lack of drainage shown by pumping)

3

1	2	X	4	5

Severe cracking with lateral displacement

5

1	2	3	4	X

Edge restraint non-functional. Sections missing.

D.3.6. Rutting

Ruts are parallel depressions of the surface in the wheel paths.

Possible causes

Rutting results from compaction or shear deformation through the action of traffic and is limited to the wheel paths. It is usually caused by inadequate compaction and/or strength in the pavement layers below the paving blocks. The wider the area affected by the rutting, the deeper the cause of the problem is beneath the pavement surface.

Table D.8: Description of degrees of rutting

Degree	Description
1	Difficult to discern unaided. Deformation under a 2m straight edge is less than 5 mm.
3	Readily discernible, and typically between 10 and 15 mm under a 2 m straight edge.
5	Severe and dangerous, with rutting exceeding 25 mm under a 2 m straight edge.

The assessor is not expected to measure rut depths using a straight edge, but for calibration purpose rutting is defined as the maximum deviation measured under a two metre straight edge placed transversely across the rut.

RUTTING

1

X	2	3	4	5

Rutting present but difficult to discern. < 5 mm

3

1	2	X	4	5

Easily discernible. Between 10 and 15mm.

5

1	2	3	4	X

Rutting severe and dangerous. > 25mm deep.

D.3.7. Potholes / patching / reinstatements

It is often difficult to distinguish between 'missing blocks' and 'potholes'. However, any hole in the surface should be indicated as a pothole. The origin could be broken blocks that were dislodged by traffic, or man-made holes. Typically potholes are repaired with a foreign material, since it is difficult to reinstate these with blocks if there has been lateral movement.

A patch is an area where the original pavement showed signs of distress and was subsequently replaced with new pavement materials. Patches usually consist of either surface patches (only the block pavers replaced) or deep patches (subbase repairs also required). A patch is not necessarily a defect, but they do give an indication of the condition of the pavement in so far as they show the extent of previous distresses.

Occasionally a service trench reinstatement is noticeable and could be the source of distress different from the general pavement. Figure D.4 shows such an example.

Figure D.4: Noticeable trench reinstatement on a block pavement

The deterioration severity could be in terms of an open pothole, or a deteriorated patch with a foreign material. Reinstatements with paving blocks would be covered under block condition or loss of jointing sand, but when a foreign material is used it is considered to be a patch. Whether a pothole or a distressed patch, the maintenance workload is similar.

Table D.9: Description of degrees of potholes / patching / reinstatements

Degree	Description
1	No missing blocks or minimal distress on the foreign patch.
3	Single blocks missing with deformation/damage of support layers, or patches showing significant distress on the foreign patch (e.g. deformation and/or cracking)
5	Five or more blocks missing with deformation/damage of support layers, patches showing severe distress on the foreign patch (e.g. deformation and/or cracking)

POTHOLES / PATCHING / REINSTATEMENTS

1

X	2	3	4	5

No missing blocks or minimal distress.

3

1	2	X	4	5

Less than 5 missing blocks with distress of support layers

5

1	2	3	4	X

≥ 5 missing blocks with marked distress of support layers

D.3.8. Undulations / shoving

Undulations refer to structural failures that extend through the surface layer and into the underlying layers, with the accompanying shoving of blocks. Should the supporting layer (subbase) below the bedding be damaged or disturbed, the distress should be recorded as undulations / shoving. This defect is localised whereas rutting is in the direction of traffic and occurs over longer sections in the wheel paths. On rural roads undulations would also be registered during roughness measurements.

Possible causes

Moisture ingress into the pavement layers can result in the total loss of the structural capacity of the pavement and in the formation of undulations. Undulations occur when materials in weak pavement layers are displaced laterally through shear forces induced by traffic, resulting in mounds adjacent to depressions.

Severity levels

The degree of failures can generally be expressed by the diameter and depth of the depressions.

Table D.10: Description of degrees of undulations / shoving

Degree	Description
1	Minor shoving (< 10 mm) – no mounding.
3	Undulations / shoving starting. Minor depression (< 30 mm). Start of surface distress and shoving.
5	Severe undulations / shoving with loss of blocks and subbase material or severe depression (> 50 mm) and shoving.

UNDULATIONS / SHOVING

1

X	2	3	4	5

Shoving just evident. No mounding yet

3

1	2	X	4	5

Shoving starting. Minor depression (< 30 mm)

5

1	2	3	4	X

Shoving with loss of blocks or depressions deeper than 50mm

D.4. Functional Assessment

The functional requirements of a road reflect the service it provides to the road user. They are predominantly those that govern the comfort, safety and speed of travel.

The various functional features to be assessed are the roughness, skid resistance, surface drainage, condition of the shoulders and edge breaking. In this section they are assessed either on a five-point or a three-point scale (excluding edge breaking).

D.4.1. Roughness

The roughness (riding quality) of a pavement is defined as the general extent to which road users, through the medium of their vehicles, experience a ride that is smooth and comfortable, or bumpy and therefore unpleasant or perhaps unsafe. This is determined by the unevenness of the road profile (longitudinal deformation, rutting in wheel paths, etc.), deterioration of the blocks or subbase layer material (e.g. potholes) and uneven patching. The description of degrees of roughness is given in Table D.11.

Table D.11: Description of Degrees of Roughness

Degree	Description
1	Ride very smooth and very comfortable, no unevenness of the road profile, no undulations or uneven patching.
2	Ride smooth and comfortable, slight unevenness of the road profile, slight rutting, undulation or uneven patching.
3	Ride fairly smooth and slightly uncomfortable, intermittent moderate unevenness of the road profile, moderate rutting, undulation or uneven patching.
4	Ride poor and uncomfortable, frequent moderate unevenness of the road profile, frequent rutting, undulation or uneven patching, comfortable driving speed below speed limit.
5	Ride very poor and very uncomfortable, extensive severe unevenness of the road profile, extensive rutting, undulation, shoving or uneven patching, comfortable driving speed much lower than speed limit, road unsafe owing to severe unevenness.

Note: Problems resulting in high roughness should be indicated on the assessment form (if required), by marking the appropriate blocks.

These problems include:

- Potholes/failure and patches;
- Loose blocks because of loss of jointing sand;
- Undulations/settlement.

Road roughness is usually measured with an instrument on rural roads. In the urban environment it is of minor importance, as the defects will indicate the general deterioration. The road noise on block roads may be higher than on flexible pavements, often leading to an overestimate of the roughness.

D.4.2. Skid Resistance

Skid resistance reflects the general ability of the road surface to prevent skidding when wet, in all manoeuvres generally executed by vehicles. Skid resistance is usually measured with an instrument on rural roads. Paving blocks that have chamfers provide adequate escape paths for water in the tyre/surface contact area, and skid resistance is not normally a problem except in deep ruts.

The description of degrees of skid resistance is given in Table D.12.

Table D.12: Description of Degrees of Skid Resistance

Degree	Description
1	Skid resistance adequate, surface texture coarse, good chamfers. Blocks have rough texture.
3	Skid resistance intermittently inadequate. Blocks have smooth surface texture and chamfers not pronounced.
5	Skid resistance inadequate. Blocks with very smooth texture and chamfers not defined.

D.4.3. Surface Drainage

The surface drainage of a road is a measure of the general ability of the road to keep the riding surface clear of water. This is related to the speed at which water runs off during rain and to the extent of the ponding of water during and after rain. It is an important factor that can affect the skid resistance and the volume of water sprayed by traffic (affects visibility and could inconvenience pedestrians).

The description of degrees is given in Table D.13.

Table D.13: Description of Degrees of Surface Drainage Ratings

Degree	Description
1	No visible problem that could retard the run-off of water from the road and shoulders.
3	Problems exist that could lead to general slight ponding or severe localised ponding.
5	Problems exist that could lead to widespread severe ponding in the wheel paths.

Note: Problems leading to inadequate surface drainage can be indicated on the assessment form, by marking the appropriate blocks. These problems include the following:

- Profile;
- Rutting;
- Shoulders/edge restraint too high;
- Side drains, and
- Failures/depressions.

D.4.4. Shoulders

Unpaved shoulders

The unpaved shoulder is rated in terms of providing a safe recovery area. Several problems might render the unpaved shoulder unsafe, for example:

- erosion of the shoulder by water;
- wearing out by traffic;
- differences in level between edge of carriageway and shoulder;
- the width of the shoulder is too narrow;
- the cross-sectional slope of the shoulder is too steep; or
- overgrown by vegetation.

These problems can be indicated on the assessment form by marking the appropriate blocks.

The description of the degrees of unpaved shoulder conditions is given in Table D.14.

Table D.14: Description of degrees of unpaved shoulder conditions

Degree	Description
0	If the edge of the road is defined by a kerb or there are no shoulders e.g. in a mountain pass.
1	Shoulder can be safely used as stopping area at the posted speed limit.
3	Problems may be expected if the shoulder is used as stopping area at the posted speed limit (routine maintenance required).
5	Shoulder is unsafe to be used as stopping area at the posted speed limit. Scheduled maintenance required e.g regravelling or substantial work required

D.5. Summary

D.5.1. Overall condition of pavement

The description of the overall condition of the pavement is given in Table D.15. A general rating for the condition of the pavement is useful for data verification.

Table D.15: Description of Degrees of Overall Condition of Pavement

Degree	Description
1	Very few or no defects. Degree of defects less than 2.
2	Few defects. Degree of structural defects mostly less than 3
3	A few defects of degree 3 is occurring locally or seldom.
4	General occurrence of defects with degree 3.
5	Many defects. The degree of the majority of structural defects is above 3 and the extent is predominantly general to extensive.

D.5.2. Comments and other problems

Certain items requiring possible maintenance measures that are not recorded under standard defects should be noted on the assessment form. These include problems such as mechanical damage, mole damage or root damage or any other problems not listed on the form.

D.6. Assessment form

VISUAL ASSESSMENT : BLOCK PAVEMENTS

South Africa COTO Committee of Transport Officials

ROAD AUTHORITY :		ROUTE CLASS :	1	2	3	4	5		
REGION / SUBURB :		TRAFFIC :	VL	L	M	H	VH		
ROAD NO / STREET NAME :		GRADIENT :	Flat		Med		Steep		
		TERRAIN :	Flat		Rolling		Mount		
SEGMENT (FROM - TO) :									
SEGMENT DIMENSIONS :	LENGTH	m	WIDTH	m					
BLOCK SHAPE :	S-A S-B S-C		LAY PATTERN :		HB SB BW OT				
BLOCK THICKNESS (mm) :			CHAMFER :		45 R 90				

ENGINEERING ASSESSMENT

	DEGREE					EXTENT				
	MINOR		WARNING		SEVERE	ISOLATED				EXTENSIVE
	0	1	2	3	4	5	1	2	3	4	5
SPALLED / CRACKED / BROKEN BLOCKS											
BLOCK SURFACE INTEGRITY (DURABILITY)											
LOSS OF JOINTING SAND											
EDGE RESTRAINT / ANCHOR BEAM DAMAGE											
RUTTING											
POTHOLES / PATCHING / REINSTATEMENTS											
UNDULATIONS / SHOVING											

FUNCTIONAL ASSESSMENT

ROUGHNESS		1	2	2	4	5
	Problem		failures	potholes	loose blocks	undulations
SKID RESISTANCE		1	2	2	4	5
SURFACE DRAINAGE		1	2	2	4	5
	Problem	rutting	shoulders	profile	failures	side drains
SHOULDERS (unpaved)	None	1	2	2	4	5
	Problem	eroded	overgrown	inclined	too high	too narrow

SUMMARY

OVERALL PAVEMENT CONDITION	1	2	3	4	5
COMMENTS:					
OTHER PROBLEMS	service crossings	trees	moles	mechanical damage	

ASSESSOR : _____ DATE : _____