MAINTENANCE PLANNING SYSTEM FOR BLOCK PAVEMENTS

H. v.d. Beld* , P.H. Duiven** et al.
Members of Working Group R1 'Pavement Management'

Study Centre for Road Construction, Arnhem, The Netherlands

* *DHV Consulting Engineers, Amersfoort*
** *Heidemij Consultancy Group, Arnhem*

SUMMARY

This paper is concerned with a description of the maintenance planning system for block pavements developed by the Study Centre for Road Construction (SCW) for Dutch roads. Special attention is focused on common types of damage and patterns in the deterioration of pavement because they decide what maintenance is necessary, and when.
But the central theme of the paper is the recently developed SCW Inspection System, which permits objective registration of the condition of roads in a relatively simple manner. For greater efficiency, the system opted for two kinds of inspection: a general and a detailed one. In recognition of the major importance of a Catalogue of Defects in visual inspections, a modified version specially adapted to block pavings accompanies this paper as an appendix.
The authors also describe how the collected data are used towards the production of a well-founded long-term plan. This part of the SCW system is based on field data, such as panel ratings of the road network in a country municipality. The complete procedure is then discussed with concrete reference to the maintenance plan for a residential street. The paper ends with a consideration of the future of the SCW system.

INTRODUCTION

In the Netherlands, more than in most countries, block pavements are a common form of road surface. In its centuries-old city centres (such as Delft's) as well as in new residential areas, block pavements are abundant. If the total length of Dutch roads is an estimated 119,000 km, some 40,000 km of this total is of the block-paved kind.

Additionally, concrete paving blocks are often used to surface industrial estate roads exposed to heavy loads. This paper is not concerned with this category, however, and concentrates on ordinary block-paved roads.

Block pavements are particularly common on roads with a 50 or 60 km/h speed limit, streets in residential areas and precincts, parking places and cycle tracks. Footways in the Netherlands are likewise nearly always block-paved. The paving blocks in most frequent use are:

Material	Length (mm)	Width (mm)	Height (mm)
Clay bricks	210	60-100	80-100
Concrete paving blocks	210	60-100	80-100
Concrete flags	300	300	40- 60

Blocks with geometrical interlock are rarely used in the Netherlands.

This paper does not deal with the design aspects of block pavements but focuses entirely on the maintenance of such pavements. Obviously, given a road network of this size, a system is needed to aid in efficient planning and budgeting of maintenance work.

The present paper describes a system for the maintenance management of block pavements which was devised by the Dutch Study Centre for Road Construction (Studiecentrum Wegenbouw, or SCW), a non-profit organization engaged in scientific and technological researches in the field of road construction.

The key element of this system, field-tested in the municipality of Rhenen, is the visual inspection because it permits objective, rapid and relatively inexpensive assessment of the condition of roads (1). The SCW Inspection System, with the manner of processing the inspection results, therefore constitutes the core of this paper. The paper further shows how the results of inspection, complemented with the results of measurements (insofar as deemed necessary), are used towards the preparation of a well-grounded long-term plan enabling the road manager to keep his roads in good shape at the lowest possible cost.

As an aid in road inspections, a standard catalogue of defects is indispensable because it provides the person performing the inspection with the means of uniformly recording the type of damage, its degree and its extent. Recently completed, the SCW Catalogue of Defects (2) defines all common types of damage and standardizes rating procedures. A version of this catalogue specially modified to fit block pavements is discussed in this paper and accompanies it as an appendix.

SYSTEM FOR EFFICIENT ROAD MANAGEMENT

The definition of efficient road management accepted in the Netherlands runs as follows:
"Efficient road management consists in the system and the techniques which permit optimum utilization of the available funds towards the maintenance of the road network."
Based on this ideal conception, a system has been evolved which keeps the quality of the entire district or municipal road network under control (network level) and gives early warning of the need for action when the condition of a particular road threatens to fall below the minimum limit (project level). This system goes from coarse to fine. Broad information is rapidly collected on the entire road network, and subsequently a selection is made of roads requiring closer inspection.

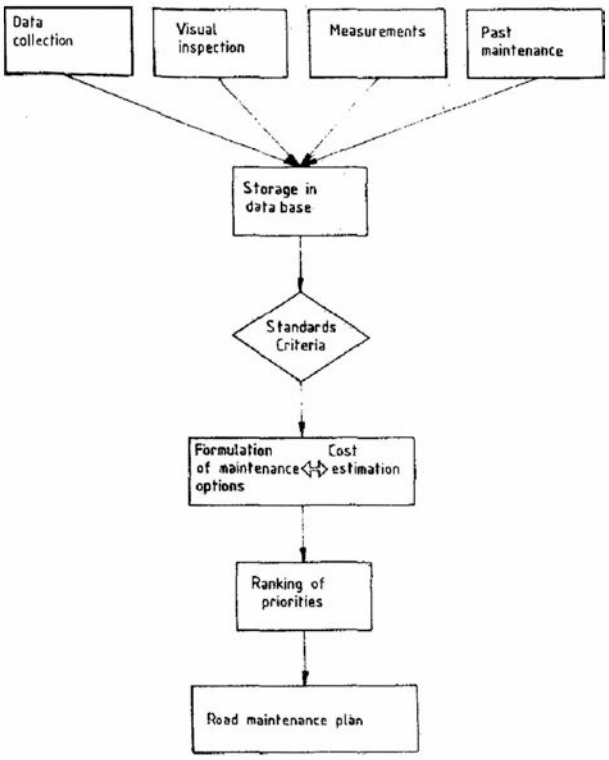


Figure 1: Maintenance planning system

It is important for the proposed efficient approach to road maintenance that a number of key data on nature, size and quality of the road network, plus historical maintenance data should be stored in a data base. After all, unless the basic data are complete and up-to-date, no satisfactory comparison and selection of maintenance options is possible.

As the state of repair and the rate of surface deterioration determine maintenance needs, periodical collection of data on these aspects is of the essence. The principal factors in the decision-making on urgency and timing of maintenance work are often unevenness of the roadway and impaired drainage capacity. Road quality is rated both by inspections and by measurements.

Visual inspections serve to rate the apparent damage to the pavement as regards degree and extent. But there are also several properties which it is difficult to rate visually, such as skid resistance, longitudinal evenness and bearing capacity. Objective data on these properties can be obtained through measurements.

Good road management requires that the condition of pavements be consistently maintained above a minimum level. To be able to ensure this, the managing authority needs standards and criteria permitting measurement of the condition of a road in relation to its function. From the data on the state of the road and the observed and projected deterioration in quality, managers can tell when a predetermined limit value (as for rut depth) will be exceeded.

Given this kind of ability it is of course also possible to establish a time schedule for maintenance work.

Next the various maintenance options are weighed per road section against their effectiveness and cost so that the most appropriate action can be chosen.

This results in a maintenance plan specifying the maintenance actions in any one year of the planning period. The maintenance plan is sufficiently flexible, however, to permit the shifting of certain actions from one year to another in response to political and financial pressures. The effects of such shifts are also quantifiable and can be allowed for. The end-result of all this is a carefully balanced plan which all parties involved understand and accept.

The maintenance plan distinguishes three planning periods:

- the period from year 5 to year 20, for which the emphasis is largely on cost prediction and optimum integration of activities in terms of both time and place;
- the period from year 2 to year 5, for which actions and costs are specified per year;
- the period from year 0 to year 2, for which both actions and costs in either of the two years are spelled out and a sequence of priorities in the maintenance work is established.

With this planning method, the cost of maintenance can be minimized. Additionally, the long-term plan functions as a policy and planning tool. Annual updates of the plan to incorporate the latest data give it a progressive character. Surprises with un-

foreseen and awkward financial consequences are thus all but eliminated.

INSPECTIONS

The aim of inspections is to observe and record the apparent damage. Various technical aspects of the road are to be investigated and for each type of damage ratings of its degree and extent are to be assigned. To meet this aim the SCW Inspection System described below was devised.

The SCW Inspection System is the outcome of the Rhenen pilot project in the year 1977, in which experience was gathered with two other systems (3,4). These systems derived from existing inspection systems for asphaltic pavements, and for the first time listed the types of damage peculiar to block pavings.

One of the findings of the pilot project was that detailed inspection of all roads was impracticable and unrealistic. The SCW system therefore distinguishes between a general and a detailed inspection.

The general inspection rapidly and efficiently gathers data on the state of repair of all roads in the road manager's care (network level). Next, those roads which are shown by the general inspection to require early maintenance (within the next 2 to 3 years) are subjected to a fuller inspection (project level).

In this two-tiered approach there obviously has to be a link between the two tiers. This correlation is illustrated in the table below.

Table 1: Relation between general and detailed inspection (simplified version)

DETAILED INSPECTION / GENERAL INSPECTION: degree of damage / extent of damage / RATING	SLIGHT				MODERATE			SEVERE		
	very slight	slight	moder-ate	consid-erable	slight	moder-ate	consid-erable	slight	moder-ate	consid-erable
1 : GOOD	X									
2 : FAIR		X								
3 : INDIFFERENT			X		X					
4 : POOR				X		X				
5 : VERY POOR							X	X	X	X

Types of damage in block pavements

Towards the registration of the apparent damage, the catalogue which is part of the SCW system defines the principal types of damage. Types which somehow belonged together were grouped in classes: in this way five different classes were formed.

Table 2: Classes and types of damage

CLASS	DAMAGE TYPE
TEXTURE	• Reduced skid resistance
EVENNESS	• Transverse unevenness • Surface irregularities • Longitudinal unevenness
INTEGRITY	• Holes • Deformed joints • Damage to paving blocks
MARGINAL STRIP	• Damage to road edge • Damage to kerbs
MISCELLANEOUS	• Ineffective surface drainage • Damage to shoulders • Damage to parking-strips/bus stops

As was suggested above, the types of damage which are the chief occasion of (large-scale) maintenance to block pavements are irregularities, transverse unevenness, longitudinal unevenness and also ineffective surface drainage. In cycle tracks, particularly, deformation of the joints between paving blocks is an important maintenance criterion.

Reports on the other kinds of damage often provide supplementary information, the main importance of which is that it helps in deciding on the nature and extent of the most appropriate action and in determining the maintenance priority.

The SCW Catalogue of Defects appended to this paper defines each type of damage and contains instructions on the rating of its degree and extent. In the original catalogue, photographs of all damage types are given, but the modified catalogue presented here contains only a selection of these photographs.

General inspection

The general inspection serves to obtain data on the condition of the entire municipal network of roads without wasting either time or money. Hence this kind of inspection is usually conducted from a car in bottom gear or from a bicycle.

For each class, the state of repair of the road is rated on a 5-point scale. Ratings assigned are based on an assessment of both degree and extent of the damage within the class considered.

1 = good : No damage or slight damage of very slight extent.

2 = fair : Slight damage of slight extent.

3 = indifferent: Slight damage of moderate extent and/or moderate damage of (very) slight extent.

4 = poor : Slight damage of considerable extent and/or moderate damage of moderate extent.

5 = very poor : Moderate damage of considerable extent and/or severe damage.

Figure 2 presents a completed general inspection record.

GENERAL VISUAL INSPECTION

Name of road: Sweelinckstraat
Road No.: 0409 Section: 03
From: Verdistraat
To: Bachstraat
Length 163 m

Date: 27-3'83
Inspectors: Waanders/Steggehuis
Weather: ☒ clear ☐ light cloud ☐ overcast
Road surface: ☒ dry ☐ drying ☐ wet

		CW L	CW R	CT	FW	PS	CW L	CW R	CT	FW	PS	CW L	CW R	CT	FW	PS	CW L	CW R	CT	FW	PS
	Part of road																				
	Lane																				
	Pavement	CF					CB					CB					CF				
TEXTURE	Reduced skid resistance																				
EVENNESS	Transverse unevenness																				
	Surface irregularities	4		X			5		X			5		X			3		X		
	Longitudinal unevenness																				
INTEGRITY	Holes																				
	Deformed joints																				
	Damage to paving blocks	2					2					3		X			2				
MARGINAL STRIP	Damage to road edge																				
	Damage to kerbs	2					2					3		X			2				
MISCELLANEOUS	Ineffective drainage	2	p	g	s		3	p	g	s		3	p	g	s		2	p	g	s	
	Damage to shoulders	–	-	-	c		–	-	-	c		–	-	-	c		–	-	-	c	
	Damage to parking strips/bus stops	pav. B					left 3					right 5					pav. B				

SERVICE-DEPARTMENT

REMARKS

PROPOSED IMMEDIATE MAINTENANCE: replace 5 flags in footway near No. 24

CW = Carriageway
CT = Cycle track
FW = Footway
PS = Parking strip

CB = Concrete blocks
CF = Concrete flags
B = Bricks

Figure 2: General inspection record

The rating recorded for each class is the rating for the worst item in that class, which is marked by a cross.
Crosses are also placed opposite skid resistance and longitudinal evenness if measurements are to be made.
Where ineffective surface drainage is diagnosed, the probably cause(s) are indicated. They are incorrect profile of the roadway (circle p), blockage of gulleys or gutters (circle g) and misalignment of the shoulder (circle s).

Opposite shoulder, the inspector notes what, if anything, is amiss: whether the shoulder is too high (+) or too low (-), or whether its condition in terms of evenness, bearing capacity or firmness is at fault (c).

Other relevant information can be recorded under Remarks. If the inspection reveals minor damage requiring prompt attention a proposal for immediate maintenance is formulated in the appropriate space of the inspection record.

Detailed inspection

In a detailed inspection the individual types of damage are rated separately, with both degree and extent of the damage being assessed. Detailed inspections are usually made on foot.
The degree of damage is reported as slight, moderate, or severe; the extent is expressed as a percentage, or in terms of the number of defects per unit length or unit area.
The catalogue (see Appendix) describes the types of damage and illustrates them with photos and sketches.
As a rule, detailed inspections are only performed if in the general inspection a rating of 3, 4 or 5 was assigned. But exceptions may be made if warranted by the importance of the road.

DETAILED VISUAL INSPECTION

Name of road: Sweelinckstraat
Road No.: 0409 Section: 03
From: Verdistraat
To: Bachstraat
Length 163 m

Date: 6-5'83
Inspectors: Waanders/Steggehuis
Weather: ☒ clear ☐ light cloud ☐ overcast
Road surface: ☒ dry ☐ drying ☐ wet

			CW L	CW R	CT	FW	PS	CW L	CW R	CT	FW	PS	CW L	CW R	CT	FW	PS	CW L	CW R	CT	FW	PS
	Part of road																					
	Lane																					
	Pavement		CF					CB					CB					CF				
			code	slight	number	severe		code	slight	number	severe		code	slight	number	severe		code	slight	number	severe	
EVENNESS	Transverse unevenness	%		30	2				20					3	3							
	Surface irregularities	No.		15	12	1			13	10	3			5	12	7			4	4		
INTEGRITY	Holes	No.																				
	Deformed joints	%							15					10	5							
	Damage to paving blocks	%							10					5					5			
MARGINAL STRIP	Damage to road edge	m																				
	Damage to kerbs	m												5								

SERVICE-DEPARTMENT

REMARKS: CW: 2 severe surface irregularities near manhole

PROPOSED IMMEDIATE MAINTENANCE

Figure 3: Detailed inspection record (For codes see Figure 2)

Rules for inspections

To ensure that visual inspections are performed correctly certain rules should always be observed. The two principal ones standardize methods of measurement and interpretation.

Aids in measurement

The following standard aids should be used at all times to measure degree and extent of damage:

- a 1.20 m long rule;
- a graduated stick or wedge;
- a 5 m long piece of string;
- 5 mm and 10 mm dia. gauge pins;
- the catalogue of defects.

Interpretation

Consistency in damage ratings depends on the inspector's ability and willingness to stick to the catalogue. It is therefore necessary that the inspectors should have sufficient practical and theoretical training in its use and interpretation.

MEASUREMENTS

Besides visual inspections, the Maintenance Planning System uses instruments to obtain data on the condition of the pavement. Measurements relevant to efficient pavement management are listed in Table 3.

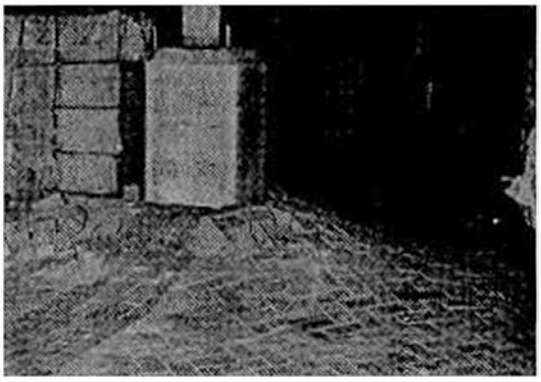
Especially frequent are measurements of skid resistance and longitudinal evenness.

Skid resistance is a key parameter in arterial roads with traffic speeds in excess of 50 km/h. Additionally, skid determinations on intersections may be useful to verify whether pavement friction is still sufficient to prevent collisions.

Evenness measurements are particularly important in road types where the discomfort and expense to users are at issue: they are therefore practically restricted to pavements of carriageways and cycle tracks. Transverse (un)evenness measurements are occasionally performed instead of or in support of visual inspections.

Measurements to establish the bearing capacity of block pavements are seldom made. The only circumstances in which they could be useful are when serious doubts have arisen on the bearing capacity of subbase or subsoil of roads with a high traffic density.

In areas where settlement of the soil is a problem the general subsidence of the pavement may determine the timing of maintenance. On such roads determinations of settlement may therefore occasionally be made. They consist in taking readings of the difference in level between pavement and benchmarks.



Example of large settlement

Table 3: List of relevant measurements

Class of road	Characteristic: Speed km/h	Characteristic: Marshall cal. (ref.6)	Characteristic: Average daily traffic (a.d.t.)	Measurements: Traffic intensities	Measurements: Skid resistance	Measurements: Tranverse evenness	Measurements: Longitudinal evenness	Measurements: Bearing capacity
Residential street	30	4	3600			•		
District street	50	4	3600			•		
Major district street	50	3	3600	•	o	•	•	supplementary
District thoroughfare	50	2	18000	•	o	•	•	
Urban access road	50/80	2	18000	•	•	•	•	

• relevant
o less relevant

PROCESSING OF DATA FROM INSPECTION AND MEASUREMENT

Visual inspections and measurements together produce a wealth of data on the state of repair of the individual roads. As these data are grouped and processed, a picture of the quality of the entire road network emerges, and with it the basis for a long-term plan and maintenance budget.

Figure 4 illustrates the conversion of the data into the maintenance plan.

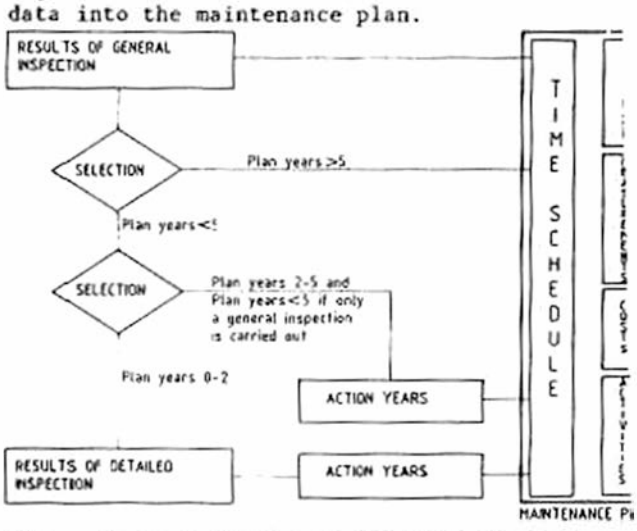


Figure 4: Flow diagram of planning process

Along the way, the maintenance activities are broken down into three kinds: long-term (>5 years), medium-term (2 - 5 years) and short-term (0 - 2 years). To derive a time schedule from the inspection data the road manager needs to know the residual life of the pavement. This is therefore the next subject to be considered in this paper.

RESIDUAL LIFE

To prevent the condition of a pavement from falling below the tolerance limit the development of the damage should be on record. To this end, periodical inspections (and, in some cases, measurements) are necessary. Another approach to the problem is based on typical behaviour patterns describing the probable development of the damage (e.g. rut formation) in time. Given such patterns it is possible to tell, starting from the observed condition of the road, when maintenance is due. The period between the time of visual inspection and the time of maintenance is called the residual life of the pavement.

Although the history of block pavements in the Netherlands covers many centuries, studies of the deterioration of this type of pavement are limited in number and scope. Neither have foreign studies produced any typical behaviour data suited for use in the Netherlands. It follows that, for the time being, the field data will have to be analyzed on the basis of the road managers' professional experience and the findings of the Rhenen pilot project.

The pilot project showed that most block-paved roads with traffic densities under 4,000 vehicles have a life of 14 - 20 years judged by the criteria of evenness (transverse unevenness, surface irregularities). Shorter lives may occasionally occur but then there is usually an identifiable cause, such as a high rate of settlement of the subsoil or dubious quality of the subbase. In the interpretation of inspection and measurement data, allowance may therefore be made for this general behaviour. Although in principle the other types of damage (affecting skid resistance and integrity) could also be a maintenance criterion, their infrequency makes them unsuitable as road life indicators. Poor surface drainage is an important indicator in any one road affected by it but has no general predictive value.

For the purpose of gathering additional data for planning use, a panel rating was organized in 1981 in the municipality of Rhenen (7). In it, sixteen experts estimated residual life and future maintenance requirements of a number of roads, on the basis of the available data on construction and past maintenance. General inspections were performed separately, and the two sets of results were integrated with each other.

Figures 5 and 6 present the relationships. A subsequent panel rating one year later gives a similar picture of residual life.

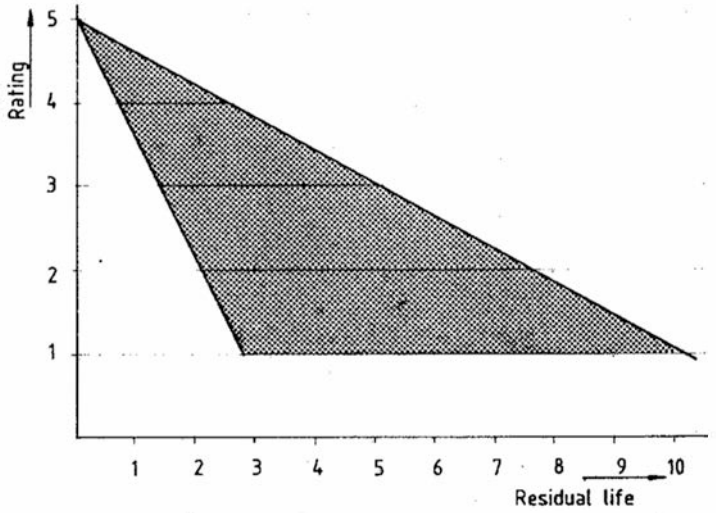


Figure 5: Relation between general inspection ratings and residual life (1981 panel rating)

The panel rating further shows that estimates of the residual life of block pavements of recent date are overconservative, since actual life (as apparent from field data) is always longer than estimated life.

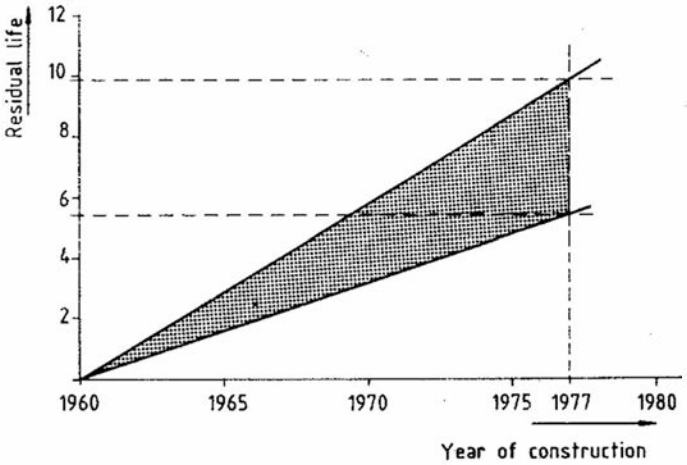


Figure 6: Relation between residual life and year of construction (1981 panel rating)

For example, a road constructed in 1977 (and thus 4 years old at the time of inspection) was estimated to have a residual life of 5 - 10 years. Total life would thus be 9 - 14 years, which is significantly shorter than the statistical mean. Possibly the reason for this deviation lies in the fact that block pavings undergo large, permanent deformation in the period immediately after construction. Once this initial deformation is over, the structure has acquired greater stiffness and additional damage develops much more slowly. There is thus a stabilization of the damage.

The body of field data now at our disposal supports the conclusion that the typical behaviour pattern of block pavements has something like the following shape.

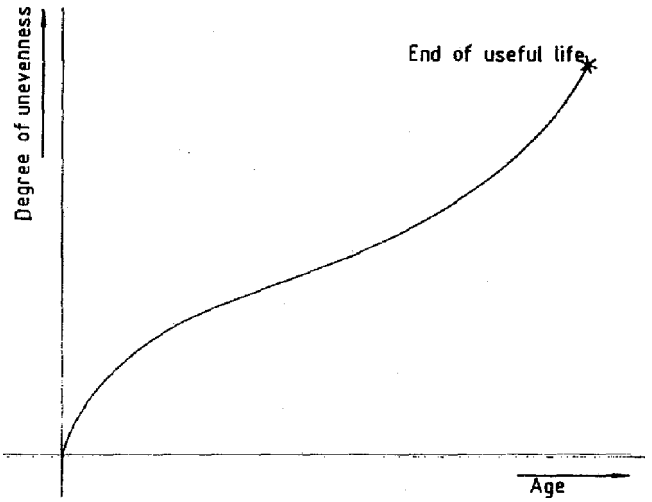


Figure 7:
Typical long-term deformation of block pavings

General inspection and residual life

In the foreseeable future the residual life of a pavement will continue to be estimated on the basis of present knowledge and experience. The following matrix correlates residual life with general inspection ratings and road age.

Table 4:
Matrix for determination of residual life

General inspection ratings	Age (years)					
	3	5	8	11	15	20
1	> 5	> 5	> 5	> 5	> 5	> 5
2	> 5	> 5	> 5	> 5	> 5	> 5
3	> 2	> 3	> 4	> 5	> 5	> 5
4	0-2	1-3	2-4	2-5	3-6	3-6
5	0-1	0-1	0-2	0-2	0-3	0-3
	Residual life (years)					

Given these data on residual life, the road manager can allocate the maintenance work among the three periods of the plan. Supplementary information from the data base on such factors as road service class and traffic density then helps him fix the near-term priorities.

Detailed inspection and residual life

The detailed inspection refines the picture of the damage in the classes Evenness, Integrity and Marginal Strip, because the degree and extent of each type of damage are ascertained. Table 5 then furnishes the translation of detailed inspection ratings to general ones. Thus, 10 moderate irregularities on 100 m of road corresponds with a rating of 4 in the general inspection. If the road section in question is 11 years old the residual life is 2 - 5 years. Once this figure is known, the precise year within the period can be selected on the basis of the detailed information on the damage, with the supplementary data from the data base.

Table 5: Relation between general and detailed inspection (full version)

DETAILED INSPECTION / GENERAL INSPECTION		DEGREE AND EXTEND OF DAMAGE									UNIT
		SLIGHT				MODERATE			SEVERE		
		0-1	1-15	16-30	> 30	0-15	16-30	>30	0-15	16-30	> 30	• % of the total area for: - transverse unevenness - deformed joints - damage to paving blocks • m. per 100 m. road length for: - damage to road edge - damage to kerbs
		0	1-7	8-15	>15	1-7	8-15	>15	1-7	8-15	>15	• Number of surface irregularities 100 m. road length
		0	1	2-5	>5	1	2-5	>5	1	2-5	>5	• Number of holes per 100 m. road length
RATING	1	X										
	2		X									
	3			X		X						
	4				X		X					
	5							X	X	X	X	

Measurements and residual life

If measurements were made to gather more details on a specific type of damage, the results are combined with those of the inspections to find residual life.

Based on experience and researches in the Netherlands and abroad, the SCW has evolved standard values. Table 6 presents these standard values for skid resistance and evenness.

Table 6: Standard values

Parameter	Unit	Class of road: Residential street / District street	Major district street / District thoroughfare / Fourth class road / Other roads	Urban access roads / Third class road	Second class road / First class road	Min./max. acceptable value
Skid resistance	Av/coefficient of friction 86%slip per 100 m.		0,31 0,45	0,38 0,45	0,38	min. desired.
Longitudinal evenness	Bump integrator value in m/km. per 100 m. vehicle speed 50 km/h.	4,0	3,2	2,7	2,4	max.
	vehicle speed 30 km/h.	5,0	4,0	3,3	3,0	max.

While it is true that the interpretation of the results of measurements requires much further study, road managers can draw conclusions on residual life from a comparison of measured with standard values. If desired, the measurements may be repeated periodically to keep track of the deterioration in quality.

From residual life to long-term plan

Once all the data of general and detailed inspection and measurements have resulted in a rating for the condition of each of the sections of the road network, the sections are distributed among the three planning periods (long-term, medium-term and short-term).

For the long- and medium-terms now only a cost forecast is prepared, plus a grouping of activities by time and place. But for road sections requiring short-term attention both the year and the extent of the activities have to be defined as closely as possible, together with the financial consequences. Apart from that, the road manager has a natural wish first to tackle the roads which exhibit the worst damage, in light of their importance to traffic. The information from the data base and the data on the maintenance measures planned (including cost data) together constitute the groundwork for the maintenance plan.

MAINTENANCE MEASURES AND EXPENSES

Maintenance to block pavements takes just a few forms; the main differences are quantitative rather than qualitative, in terms of the area to be relaid. The following types of maintenance are regarded as major, and require formal planning:

- local relays (areas > 50 m^2);
- re-placement of kerbs;
- complete relays;
- reconstruction.

In addition there is the so-called minor maintenance. This term denotes maintenance work of very limited extent which has to be executed almost at once if accidents are to be prevented. Examples could be highly localized severe irregularities in the carriageway or in cycle tracks and footways. Minor maintenance is in principle not included in the formal planning procedure and hence requires a budget of its own. It is a means of forestalling complaints and of dealing promptly with the sudden emergence of unsafe situations.

The data of the detailed inspection are particularly helpful in choosing the kind of maintenance called for, and in determining its scope.
A decision to reconstruct the road usually means that the subsoil or roadbase needs to be improved, that drains are to be laid, or that the pavement is to be given a proper foundation. In the case of such a drastic and costly operation the importance of wide-ranging historical information covering construction, inspections, measurements and maintenance expense is especially conspicuous.

Alternative maintenance measures are costed on the basis of standard prices and ideally the option with the best cost-benefit ratio is chosen, though at times the broader economic and political realities may intervene.

The table below presents a survey of the effects of maintenance measures related to the various classes and types of damage.

Table 7: Effectiveness of remedial action

ACTION	CLASS: Texture	Evenness	Integrity	Marginal strip	Miscellaneous	REMARKS
Partial relaying of pavement		x	x	o	o	Restricted to correction of local transverse unevenness and surface irregularities
Partial relaying of pavement including kerbs		x	x	x	o	
Complete relaying of pavement		xx	xx	xx	xx	
Laying of new pavement / reconstruction	xx	xx	xx	xx	xx	Indicated when condition of existing paving-blocks is poor

xx : Much better
x : Better
o : Possibly some improvement

FORMULATION OF A MAINTENANCE PLAN

The foregoing pages detailed the individual steps in the genesis of a long-term plan for the maintenance of block pavements. This section will illustrate the entire procedure by means of a concrete example. Figure 4 shows the steps.

The road section in question has a length of 163 metres and is part of a residential street located within the builtup area. The cross-sectional components of the road are:

- a footway (length 163 m, width 2.10 m, grey concrete flags);
- a carriageway (length 163 m, width 6.00 m, concrete paving blocks);
- a cycle track (length 123 m, width 1.80 m, red concrete flags);
- parking bays (distributed over both sides of the road; width 2.00 m, clay bricks).

The road was constructed in 1968 and there has been no major maintenance since. A general inspection of the road section was conducted and the results were reported on the inspection record (Figure 2). It is clear from them that the condition of footway and carriageway is poor to very poor. The quality of the cycle track is indifferent.

Next, the residual life is read from the matrix (Table 4). For an age of 15 years and a rating of 5 the residual life of the carriageway is found to be 0 - 3 years. Maintenance is therefore needed in the near term to prevent the damage becoming unacceptable.

The subsequent detailed inspection (Figure 3) reveals that the damage in the carriageway is of fairly large extent and that irregularities are in the severe category. The damage in the pavement of the footway is distributed, and the damage in the cycle track is in the main localized. Degree and extent of the damage, combined with the function of the road, point to a residual life of 1 year. No measurements were conducted.

Seeing that the skid resistance was judged sufficient and that the condition of the paving blocks ranged from fair to good, the maintenance plan does not have to allow for replacement of the paving materials. The following maintenance measures are therefore scheduled:

Year: 1984

Footway	Relay completely
Carriageway	Relay completely
	Realign some 10 m of kerb
Cycle track	Relay locally (approx. 40 m
Parking bays	Relay completely

Some such planning exercise as the above is carried out for all road sections; subsequently, the maintenance activities and relevant expenses are incorporated in the long-term plan. Table 8 is a specimen of such a long-term plan.

Table 8: Five-year maintenance plan, with budgeted cost

ROAD NO.:	SECTION	NAME OF ROAD PART OF ROAD	ACTION	EXTENT in m² or m'	UNIT PRICE (Dfl.)	1984	1985	1986	1987	1988
			SUBTOTAL			198.0	250.2	243.5	76.6	113.6
0407	01	Seringenstraat CW	LRB	75	30.95		2.3			
0408	03	Staringstraat FWL	RCF	440	11.35			5.0		
			KR1	15	6.85			0.1		
0409	03	Sweelinckstraat FW	RCF	354	11.35	4.0				
		CW	RCB	978	18.60	18.2				
			KR2	10	9.50	0.1				
		PS	RB	240	18.60	5.4				
		CT	LRCF	40	18.40	0.7				
0410	01	Veerseweg CW	RB	1760	18.60				32.7	
			KR2	245	9.50				2.3	
		FWL	RCF	493	11.35				5.6	
		FWR	RCF	301	11.35				3.4	
			TOTAL (in Dfl 1,000)			217.4	252.5	248.9	120.6	113.6

(L)RB : (local) relaying of (clay)bricks
(L)RCB : (local) relaying of concrete blocks
(L)RCF : (local) relaying of concrete flags
KR1 : kerb repairs , kerb size 50/200
KR2 : kerb repairs , kerb size 100/200

OUTLOOK

While it is no doubt true that certain areas of the version of the Maintenance Planning System developed for block pavings require clarification and expansion, that version as a whole is now sufficiently mature to be a useful tool to every road manager. Such further development as is needed can build on the solid basis of the methods described in this paper.
One of the first steps towards further refinement and greater comprehensiveness was the installation in April 1983 by the SCW of the sub-working group "Observation and Behaviour Models" as part of the working group "Efficient Road Management". It is one of the aims of this subgroup to broaden the understanding of the typical patterns in the development of block pavement damage. This particularly applies to transverse unevenness, surface irregularities and longitudinal unevenness.

It has also become apparent that road managers feel the need for a tool which could help them rank the priorities in the execution of short-term maintenance. There already exists a tentative procedure but it requires further study before it is ready for general use. Expectations are that it will receive the SCW's official sanction in 1984.

There is ample evidence to show that, with the publication of the Manual and Catalogue of Defects for the Visual Inspection of Roads, the SCW struck out in the right direction. It has since organized fourteen training seminars for people wishing to qualify as inspectors. In 1982 and 1983 some 400 persons enrolled. In addition, some 70% of the participating road managers said they already used the system, or planned its adoption. Surely this is no mean achievement.

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A P P E N D I X

CATALOGUE OF DEFECTS

for the visual inspection of block paving

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1. INTRODUCTION

Visual inspections carried out under schemes of efficient pavement management should result in uniform records of the apparent condition of the pavement. Inspections performed by different persons should in principle yield the same results, while inspections conducted at different times should be amenable to comparison.

To help towards the realization of this ideal, the SCW system described here was devised: it consists of this catalogue and companion inspection records. For each of the five classes distinguished (Sections 2 to 6), the catalogue first introduces the constituent items and describes the general inspection, in which the condition of the road is rated on a scale from 1 to 5. Next, the detailed inspection is discussed, with the procedure for rating the individual types of defects, in terms of their degree and extent.

Photos of most types of damage or undesirable pavement condition are presented in the text.

Where repairs are encountered during inspections they are not usually rated separately. All defects to the pavement, including damage to repairs, is to be reported in the appropriate spaces of the inspection record. If desired, the space for remarks may be used to note whether the repairs are satisfactory or unsatisfactory.

Where the extent of the damage is to be expressed as a percentage of the total surface area, the figures reported should be rounded. Values up to 15 percent are to be rounded to the nearest whole number; values in excess of 15 percent are to be rounded to the nearest multiple of 5.

The correlation between the ratings assigned under the general and the detailed inspection is as follows:

1 = good : No damage or slight damage of very slight extent
2 = fair : Slight damage of slight extent
3 = indifferent: Slight damage of moderate extent and/or moderate damage of (very) slight extent
4 = poor : Slight damage of considerable extent and/or moderate damage of moderate extent
5 = very poor : Moderate damage of considerable extent and/or severe damage

The terms used in the above correlation grid to quantify degree and extent of damage are defined in the text for each type of damage individually.

2. TEXTURE

2.1 General inspection

In the general inspection of surface texture, the pavement is evaluated for skid resistance.

2.1.1 Reduced skid resistance

Skid resistance is defined in terms of the coefficient of friction between car tyre and pavement, measured by a standardized method.
However, visual indications of reduced skid resistance - such as surface wear - are often available.
Ordinarily, smooth (worn) places are first apparent in ruts.
A cross should be placed in the appropriate column of the inspection record to request skid resistance tests. No detailed inspection is made.

3. EVENNESS

3.1 General inspection

In the general inspection of evenness, the pavement is evaluated for longitudinal unevenness, transverse unevenness and surface irregularities.
For the degree of damage (slight, moderate, severe), see the description of the individual items.

The extent of the damage is defined as follows:

Extent of damage	Transverse unevenness (in % of area inspected)	Surface irregularities (per 100 m of roadway)
Very slight	<1	0
Slight	1 - 15	1 - 7
Moderate	16 - 30	8 - 15
Considerable	>30	>15

3.1.1 Longitudinal unevenness

In inspecting a pavement for longitudinal (un)evenness, an assessment is made of the degree of longitudinal variations (other than short ones) in the roadway which adversely affect safety and/or riding comfort.
Longitudinal variations which are inherent in the design of the road are to be disregarded.
The kind of variation or deformation under discussion here eludes measurement by means of the customary aids in inspections, viz the rule and the piece of string. Objective data on longitudinal unevenness can be gathered with such instruments as the bump integrator, the comfort meter and the profilometer.
A cross should be placed in the appropriate column of the inspection record to request measurement of longitudinal (un)evenness.

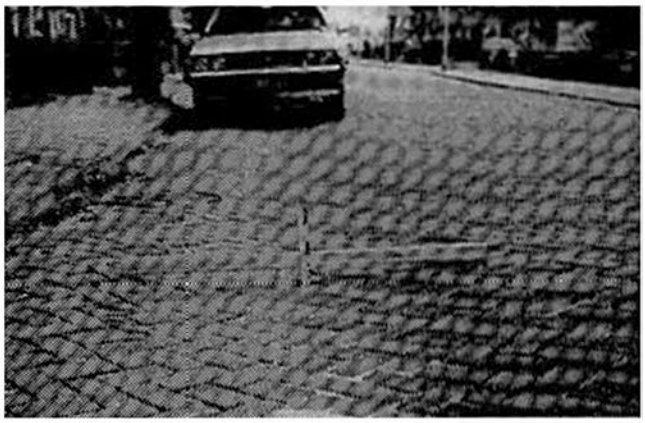
3.2 Detailed inspection

Detailed inspections are made to establish degree and extent of transverse unevenness and surface irregularities.

3.2.1 Transverse unevenness

In inspecting a pavement to establish transverse unevenness, an assessment is made of the degree and extent of vertical deformations apparent in the cross-section of the road.
Owing to deformations in the subsoil or in the road base itself, transverse unevenness may in time arise. Examples of this process are:

- rut formation;
- formation of a depression over a sewer, due to settlement.



Transverse (un)evenness is determined by means of a 1.20 m long rule placed across the roadway. The maximum clearance between rule and pavement is measured. Determinations are preferably repeated at 20 m intervals.

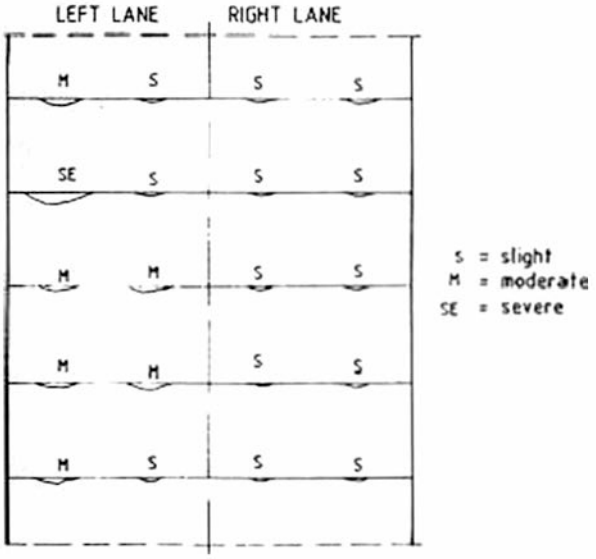




Figure 1: Registration of transverse unevenness

Degree of damage

Regarding the degree of damage the following limits apply:
Slight : Clearance is in between 5 and 15 mm
Moderate: Clearance is in between 15 and 30 mm
Severe : Clearance exceeds 30 mm

Extent of damage

The extent of the damage is determined by relating the area of affected roadway (less marginal strip) to the total area inspected and is therefore reported as a percentage.

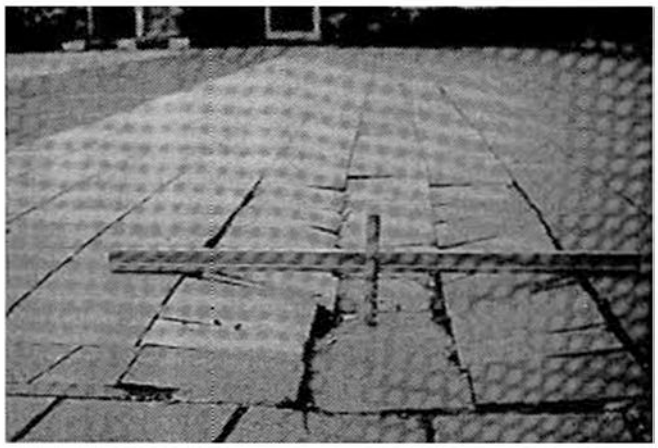
3.2.2 Surface irregularities

A surface irregularity is defined as a vertical deformation of, or a discontinuity in, the pavement which satisfies the following conditions:

- it is of relatively small extent (less than 5 m^2) but covers several paving blocks;
- it reduces the riding comfort.

Irregularities are of various kinds. If inspection of a pavement reveals any irregularities, the inspection record should therefore state the appropriate code:
D = Depression
H = Hump
TM = Transition to manhole
TK = Transition to kerb
M = Miscellaneous

Overturned paving blocks strictly speaking also belong to the surface irregularities. They are so localized, however, that they are better shown under Remarks. The area affected should be reported in square metres.



Degree of damage

The rating of surface irregularities is determined by means of a rule or, where a rule is not suitable, a piece of string. In both cases the maximum clearance (vertical distance to the road surface) is read.
Depending on these readings the irregularity is rated as follows:
Slight : Clearance is in between 5 and 15 mm
Moderate: Clearance is in between 15 and 30 mm
Severe : Clearance exceeds 30 mm

Extent of damage

Irregularities within the paved area subjected to inspection - the marginal strip excepted (see Section 5) - are counted and the total number of them is reported. If a road section has fewer than 15 irregularities, the number is reported exactly. If there are more than 15 irregularities, it suffices merely to note >15.

4. INTEGRITY

4.1 General inspection

Block pavements are evaluated for number of holes, deformed joints, and damage to paving blocks.
For the degree of damage, see the description of the individual items.

The extent of the damage is defined as follows:

Extent of damage	Deformed joints/ damaged blocks (in % of area inspected)	Holes (per 100 m of road)
Very slight	<1	0
Slight	1 - 15	1
Moderate	16 - 30	2 - 5
Considerable	>30	>5

Note

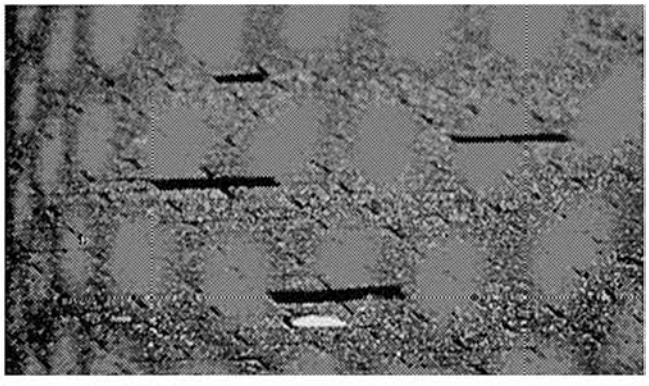
If a general inspection reveals insufficient filling of the joints this fact should be reported under Remarks.

4.2 Detailed inspection

Detailed inspections serve to ascertain degree and extent of the damage for each of three damage types (holes, deformed joints, damaged blocks) individually.

4.2.1 Holes

Any part of the roadway where the pavement has disappeared is termed a hole. Holes are reported only if they are more than 50x50 mm in size.
The depth of a hole is to be measured from its edge down, using the piece of string or the rule.



Degree of damage

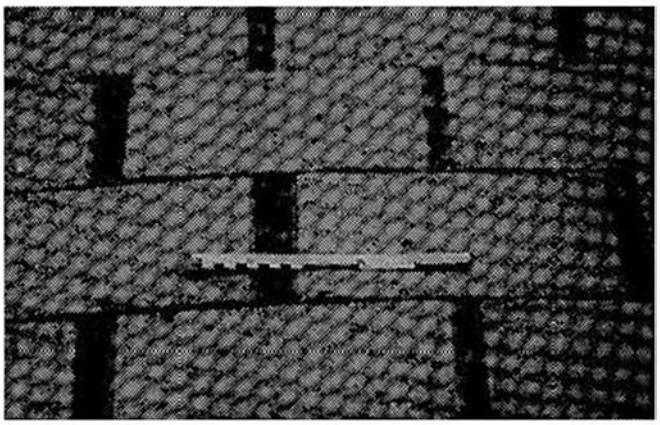
Slight : Hole depth is in between 5 and 15 mm
Moderate: Hole depth is in between 15 and 40 mm
Severe : Hole depth exceeds 40 mm

Extent of damage

The holes within the area inspected - always excluding the marginal strip (see Section 5) -are counted and the total per 100 m of road is reported. The total surface area of the holes is reported in square metres under Remarks.

4.2.2 Deformed joints

Joint deformation is a self-explanatory term for a condition the severity of which is rated by measuring the distance between adjacent paving blocks (= joint width).
In determining joint width, the person performing the inspection will tend to think that the joints are wider than they actually are: this is due to the chamfered or radiused edges of the blocks. To eliminate this effect, 5 mm and 10 mm dia gauge pins are used in estimating joint width.



Note

Insufficient joint filling should be reported under Remarks.

Degree of damage

Slight : Joint width is in between 5 and 10 mm
Moderate: Joint width is in between 10 and 20 mm
Severe : Joint width exceeds 20 mm

Extent of damage

The percentage of the inspected area which is affected by joint deformation is reported.

4.2.3 Damage to paving blocks

Paving blocks may exhibit breaks, wear and weathering. If they are found to have chipped edges, this is to be considered the effect of weathering and should be reported accordingly.



Degree of damage

Slight: The condition is such that reconstruction of the pavement using the same blocks should present little difficulty.
Some corners are missing and/or the blocks are slightly weathered.

Moderate: The blocks are not easily reusable because corners and other fragments are missing and/or because the blocks present a weathered appearance. There is soms breakage per unit area.

Severe: The blocks have lost so much of their original shape that they are no longer suited for reuse. There is extensive breakage per unit area.

Extent of damage

Always excepting the marginal strip, the total area affected by damage is expressed as a percentage of the paved area subjected to inspection.

5. MARGINAL STRIPS

5.1 General inspection

In a general inspection of marginal strips, an assessment is made of damage to road edge and kerbs.
For the degree of damage see the description of the individual items.
The extent of damage is defined as follows:

Extent of damage	Damage to road edge/kerbs (in % of road length inspected)
Very slight	< 1
Slight	1 - 15
Moderate	16 - 30
Considerable	>30

5.2 Detailed inspection

Detailed inspections are conducted to rate damage to road edge and kerbs.
Note that damage to gutters and shoulders is rated separately (Section 6).

5.2.1 Edge damage

Edge damage is defined as damage of the types discussed in Sections 3 and 4 ("Evenness" and "Integrity") occurring in a 250 mm wide strip along the edge of the pavement. For the purpose of this definition the edge of the pavement is that part of the roadway which is bounded by a gutter, a kerb or the shoulder (see Figure 2).

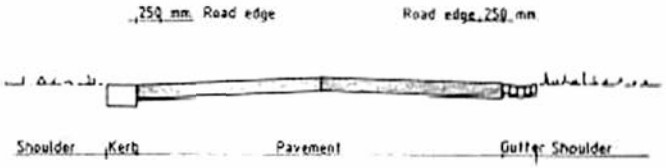


Figure 2: Location of road edge



Degree of damage

See the definitions for the degree of damage as discussed in Sections 3 and 4.

Extent of damage

The aggregate length of edge damage is reported in metres. Where it is more than 10 m it may be rounded to the nearest multiple of 5.

5.2.2 Damage to kerbs

The kerb is a (usually narrow) structure confining the roadway and providing lateral support to the pavement.
Kerbs have been known to settle without detriment to their functionality.
Where such cases are encountered they should be reported under Remarks.



Degree of damage

Slight: The support which the kerb gives to the pavement appears to be impaired somewhat.

Moderate: The support which the kerb gives is distinctly reduced though still sufficient.

Severe: The support which the kerb gives is insufficient.

Extent of damage

The aggregate length of kerb damage is reported in metres. Where it exceeds 10 m it may be rounded to the nearest multiple of 5.

6. MISCELLANEOUS

6.1 General inspection

Damage in the Miscellaneous class is assessed on the basis of general inspections only. Items reviewed are surface drainage, shoulders, and parking strips/bus stops.

6.1.1 Ineffective surface drainage

The surface drainage of a road is defined as its ability to shed water; obviously, this ability depends in large measure on the condition of the drainage system.
The surface drainage of a road is best inspected during or immediately after heavy rainfall. However, if the inspection is performed in dry weather it must take into account the following factors:

- cross-sectional profile of pavement;
- level of gutters;
- longitudinal profile of gutters;
- level and drain capacity of gulleys;
- level of shoulders.

When drainage capacity is adversely affected by accumulation of soil and debris in the gutters and/or gulleys, this should be reported under Remarks.

Ratings

Road drainage capacity is assigned a rating on the following scale:

1 = good : There is no or very slight puddling
2 = fair : There is slight puddling
3 = indifferent: There is slight puddling constituting a nuisance to traffic
4 = poor : There is moderate or considerable puddling, constituting a nuisance to traffic
5 = very poor : There is moderate or considerable puddling, constituting a major nuisance to traffic



Note that the term traffic is here used with special reference to cyclists and pedestrians.

When the drainage falls short of the design capacity, the likely cause should be indicated by cirding the appropriate code(s) on the inspection record:
p = profile of roadway is at fault;
g = gulley or gutter is blocked;
s = shoulder is too high or too low.

Puddling is rated as follows:

Extent of puddling (in % of area subjected to inspection)	
Very slight	< 1
Slight	1 - 5
Moderate	5 - 15
Considerable	>15

6.1.2 Damage to shoulder

Inspection of this part of the road largely serves to establish the general condition.

Note

If the shoulder is paved locally to afford parking space or accommodate a bus stop its condition is to be rated under 6.1.3.

Ratings

1 = good	: Shoulder is in perfect order
2 = fair	: Shoulder is all right in terms of level and is in reasonable condition
3 = indifferent	: Shoulder is 30 mm too high or too low and/or is in indifferent condition
4 = poor	: Shoulder is from 30 to 50 mm too high or too low and/or is in very poor condition
5 = very poor	: Shoulder is more than 50 mm too high or too low and/or is in very poor condition.



If the condition of the shoulder shows any deterioration particulars should be given. To this end circle the appropriate code or symbol on the inspection record:

- = shoulder too low;
+ = shoulder too high;
c = condition of shoulder is poor because of unevenness, reduced bearing capacity, softness.

6.1.3 Damage to parking strips/bus stops



These features of the road (if present) are inspected to assess unevenness of the paved surface. For rating procedure and ratings, see Section 3 ("Evenness").