5.9 Drainage (Side Ditches, Culverts and Gullies)

5.9.1 General

Two basic principles must always be remembered when inspecting drainage facilities:-

(a) water reduces safety if allowed to accumulate on trafficked surfaces of the highway

(b) the road pavement structure must be adequately drained in order to reduce maintenance liabilities and realise the design life of the road.

Whilst the effects of (a) are readily observable, those of (b) are not. World-wide research has shown that water in or under the road pavement is the major factor in the early failure of highway pavements. The inspection procedures laid down in this section have been designed to allow, as far as possible, a correct assessment of the action necessary to keep the highway in a safe condition and to avoid structural deterioration of the road pavement.

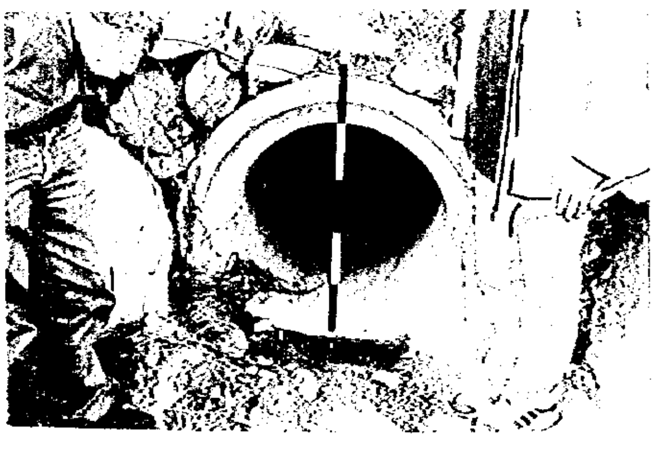
Detailed Inspections of Side Ditches and Gullies will usually only be required when repeated flooding of the road surface or adjacent land has occurred or if damage has been reported during a Routine Inspection or following maintenance work.

The flooding of adjoining landowners land should be avoided.

Polluted effluent from clearing of highway drainage should not be directed indiscriminately into watercourses.

5.9.2 Method of Inspection

The Detailed Inspection shall be carried out on foot. Sketches shall be made and measurements taken and recorded on the Detailed Inspection Sheet. Major defects should be photographed for record purposes.



Culvert Measurement with a Ranging Rod

Culvert and Accumulation of Debris Measurement with a Ranging Rod

5.9.3 Data Recording

Sample inspection sheets for Side Ditches, Gullies and Culverts are shown overleaf.

General Information
The information should be inserted before starting the inspection.

Side Ditch
Put a cross through the number representing the damage types found. If there are more than one damage type, cross all appropriate numbers.

Measure the dimensions of the side ditch and enter them on the appropriate sketch (trapezoidal, triangular or rectangular). Note that 'd' represents the depth of sediment in the ditch.

Gully
As for side ditch.

Culvert
Indicate with a cross through the appropriate number, the culvert type, damage types observed and the land use in the area adjacent to the inspection location.

Measure the dimensions and insert on the appropriate sketch (Box or pipe). The sediment depth should be recorded for the inlet and outlet as this may vary considerably.

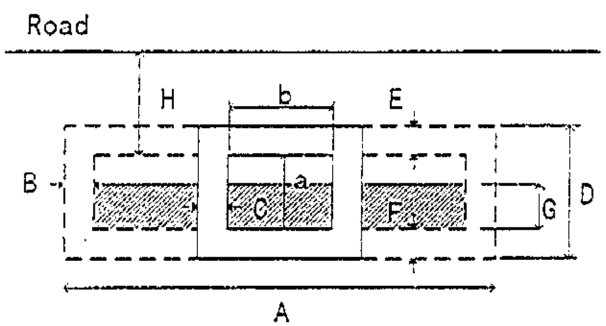
A plan and section should be drawn to locate the defect. The direction of water flow should be indicated.

Photographs of major defects should be taken.

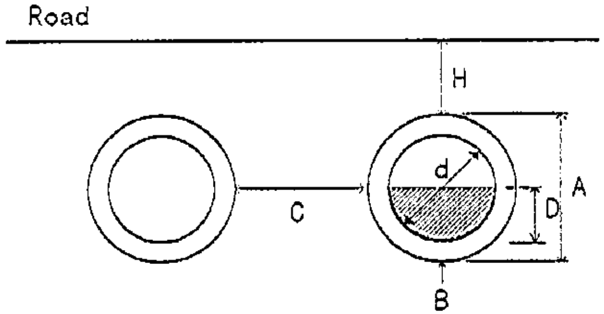
Detailed Inspection Sheet

Detailed Inspection Sheet FOR : Drainage and Culvert			Inspection Date: / /		No:
General Information	Route:	Location: km to km	Director	Chief Eng.	Inspector
	KGM-Division:	Sub-Division:			
	Road Class:	Number of Carriageways:			
	Number of Lanes:	Direction: to			
	Year of Construction:				

Drainage & Culvert			Defects Observed
	Culvert Type	(1) Box (2) Pipe (3) Other	
	Damage Type	(1) Accumulation of Debris (2) Collapse (3) Settlement	
	Land Use	(1) Residential (2) Urban (3) Industrial (4) Farm (5) Forest (6) Others	



A= B= C=
D= E= F=
G= H=
a= b=



A= B= C=
D= H=
d=

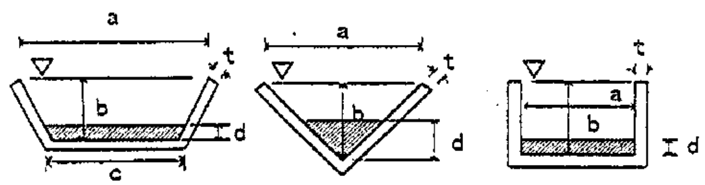
Version1 08/97

Detailed Inspection Sheet FOR : Drainage for Slope

Inspection Date: / /   No:

Drainage for Slope

Drainage System	(1) Berm Ditch (2) Crest Ditch (3) Toe Ditch
Damage Type	(1) Accumulation of Debris (2) Collapse (3) Settlement
Land Use	(1) Residential (2) Urban (3) Industrial (4) Farm (5) Forest (6) Others



a=	a=	a=
b=	b=	b=
c=	d=	d=
d=	t=	t=
t=		

Defects Observed:

Version1 08/97

Detailed Inspection Sheet

Detailed Inspection Sheet FOR : Side Ditch and Gully

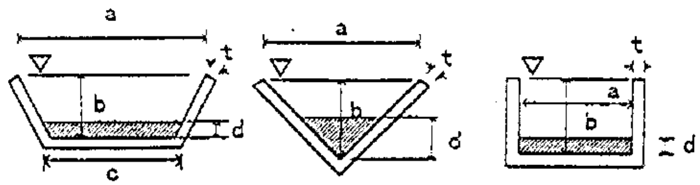
Inspection Date: / / No:

			Director	Chief Eng.	Inspector
General Information	Route:	Location: km to km			
	KGM-Division:	Sub-Division:			
	Road Class:	Number of Carriageways:			
	Number of Lanes:	Direction: to			
	Year of Construction:				

Side Ditch

Damage Type: (1) Accumulation of Debris (2) Collapse (3) Settlement

Dimension



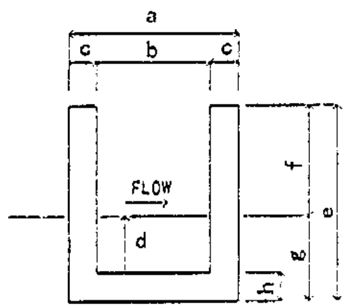
a= b= c= d= t=	a= b= d= t=	a= b= d= t=

Defects Observed:

Gully

Damage Type: (1) Accumulation of Debris (2) Collapse (3) Settlement

Dimension



a=
b=
c=
d=
e=
f=
g=
h=

Defects Observed:

Version1 08/97

5.10 Retaining Wall

5.10.1 General

Retaining wall defects may develop into more serious and more expensive problems if left unattended. Wall material may block the road or retained material may spill onto the road with the risk of a major slip. It is therefore important to observe the wall condition and that of the retained material as soon possible after the defect is reported.

5.10.2 Method of Inspection

The Detailed Inspection shall be carried out on foot. Sketches shall be made and measurements taken and recorded on the Detailed Inspection Sheet.

The condition of the retained material should be observed looking for signs of potential slips, settlement or collapse so that appropriate action can be taken to prevent a safety hazard developing.

The slope of the wall and of the retained material should be measured with a ranging rod and inclinometer

Major defects should be photographed for record purposes.

Retaining Wall measurement with a Ranging Rod

5.10.3 Data Recording

A sample inspection sheet for retaining walls is shown overleaf.

(1) General Information

The information should be inserted before starting the inspection.

(2) Inspection Items

Structure Type
Put a cross through the number of the appropriate structure type.

Damage Type
Put a cross through the number of any damage types observed.

Soil Type
The soil type should be marked. Where it is a mixed soil type, more than one type may be marked e.g. sand and clay.

Weep Hole
Put a cross through number (1) if weepholes are observed. Put the size and spacing in the box below.

(3) Sketch

Measure and insert on the inspection sheet all of the dimensions that are readily accessible.

(4) Section

A section should be drawn showing any collapse, settlement or displacement of the wall. The condition of the retained material should be indicated.

(5) Plan

A plan should be drawn to show the location of the defect.

Photographs of major defects should be taken.

Slope Angle of Wall being Measured with a Ranging Rod and Inclinometer

CHAPTER 6 SNOW AND ICE FACILITIES

6.1 General

This section sets out the requirements and advice for winter road maintenance and snow and ice control facilities on both state and provincial roads in Turkey.

6.2 Purpose of Winter Road Maintenance

The purpose of winter road maintenance is to secure the drivers' safety and the road traffic movement in winter season.

6.3 KGM's Role for Winter Road Maintenance

KGM provides a winter road maintenance service to secure winter road traffic, in co-operation with the agency for traffic administration (the police) and road user (the driver).

KGM is responsible for the reduction of hazards due to snow and ice, which threaten the driver's safety and obstructs the traffic movement This should be done by careful selection of possible and effective preventive measures, taking local conditions into account, including such works as ;

- Improvements in safer driving through driver education
- Collection of weather and road surface information and the provision of this to the road users
- Control of traffic

6.4 Period of Winter Road Maintenance

The period of winter road maintenance varies considerably from division to division. The periods defined for operational purposes are shown in Table 6.4.1.

Table 6.4.1 Period defined for Operational Purposes

Division	Months	Division	Months
1. Istanbul	3	7. Samsun	3
2. Izmir	2	8. Elazig	5
3. Konya	3	9. Diyarbakir	2
4. Ankara	3	10.Trabzon	3
5. Mersin	2	11. Van	5
6. Kayseri	3	12. Erzurum	5

6.5 Patrol and Inspection of Winter Road Conditions

It is advisable that the inspection of winter road conditions is made by patrol on a regular basis. The frequency should be determined after consideration of the local meteorological, topographical and traffic conditions.

The Inspection items are as follows:-

(a) Weather conditions,
  What are the present local weather conditions?
  How are the local weather conditions changing?

(b) Road surface conditions,
  In which sections is the road surface covered with snow, ice or water?
  How thick is the snow, ice or water on surface?
  How is the surface condition changing?

(c) Traffic conditions,
  How is the traffic movement?
  Are vehicles equipped with chains?
  Is any vehicle in trouble on road due to bad surface conditions?

(d) Snow removal and ice control operations,
  Should snow removal or ice control operation start?
  Is the operation going on properly, if now in operation?

It is desirable that the results of the inspection are not only conveyed to Sub-Division Headquarter in word, but are also recorded in a standard report format, even when there is no special noted matter, for the future use in statistical analysis.

6.6 Snow Measurement

Snow measurement must be done as a daily routine at Sub-Divisions and Workstations. The time should be unified in all Divisions in Turkey, preferably at 8:00am.

Measurement of the four principal items listed below is necessary for basic data collection.

1. Weather at 8:00am..
2. Snow depth at 8:00am.
3. Daily snowfall amount during the 24 hours from 8:00am yesterday.
4. Daily maximum and minimum air temperatures during the 24 hours from 8:00am yesterday.

Measurement results must be recorded on a standard report form similar to Table 6.2.

Table 6.6.1 Record of Snow Measurement

Division	
Measurement Time/Date	8:00AM on
Comments on weather etc.	

Measurement Items	Unit	Sub-Div.	W/S 1	W/S 2	W/S 3	W/S 4	W/S 5
Weather							
Snow Depth	cm						
Daily Snowfall Amount for Last 24h	cm						
Max. Air Temp.	°C						
Min. Air Temp.	°C						

W/S = workstation

The measured data shall be reported to the Sub-Division immediately after the measurements have been taken and recorded. The Sub-Division shall submit them to Division Headquarters daily. Monthly totals are prepared and submitted to KGM Headquarters. The procedure is shown in Fig. 6.6.1.

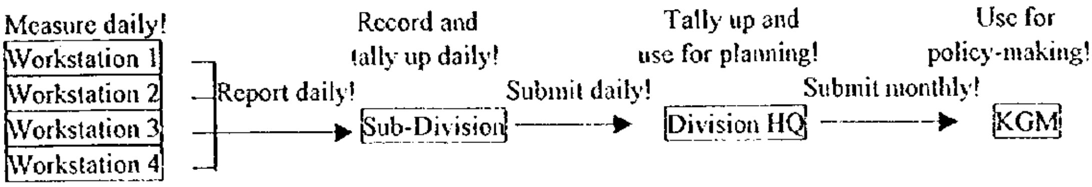
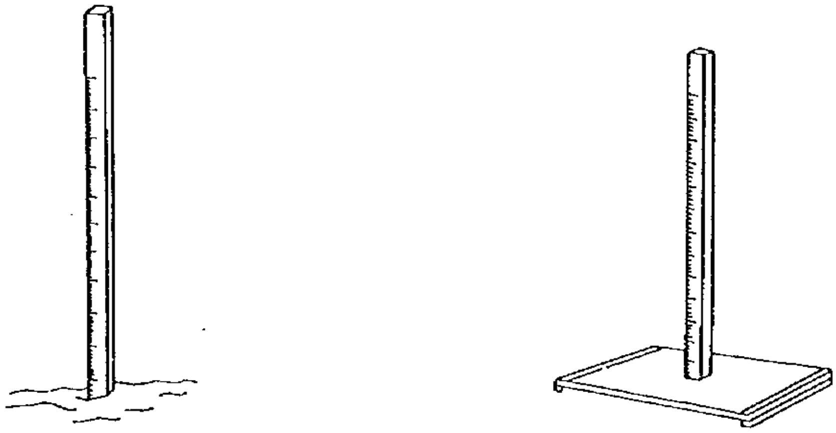


Fig. 6.6.1 Report and Submission of Snow Measurement Data

The measured data is useful at the Division for the selection of proper snow and ice countermeasures and also for the strategic prioritization of their installation sites. Without this data and the statistical analysis, it is impossible for KGM to evaluate a nationwide well-balanced deployment of snow and ice countermeasures and to make the optimum investment policy for the winter road management.

Measurement is simple and easy and some measurement devices are shown in Fig. 6.6.2



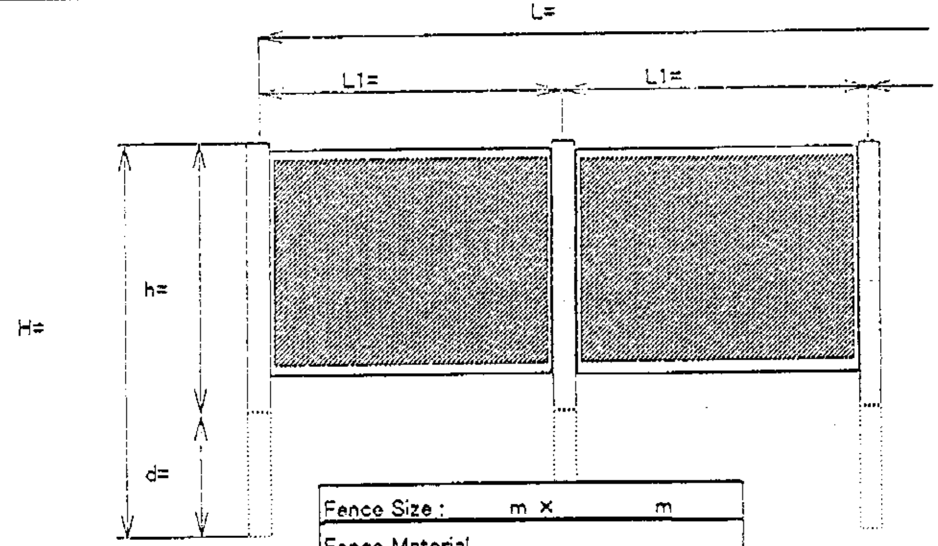
(1) Snow Depth Meter (2) Snowfall Depth Meter

Fig. 6.6.2 Measurement Devices

Detailed Inspection Sheet

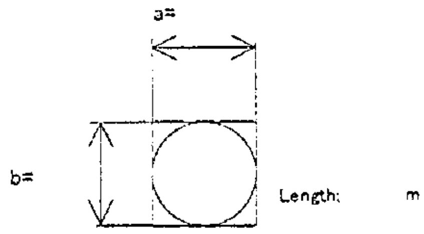
Detailed Inspection Sheet for: SNOW/ICE CONTROL FACILITIES				Inspection Date: / /		No.
General Information	Route:	Location: km to km		Director	Chief Eng.	Inspector
	KGM-Division:	Subdivision:				
	Road Class:	No. of Carriageways:	No. of Lanes:			
	Direction: to					
	Year of construction:					
Inspection Items	Survey Items	(1)Snow fence (2) Tree fence (3)Tunnel (4) Forest plantation (5)Terrain modification				
	Damage type	(1) Collapse				
	Comment					
Sketch	Sketch for Plan					
	Sketch for Section					

Sketch for Fence dimensions



Fence Size :	m × m
Fence Material	

Snow Fence



Post material: (1) Wooden (2) RC (3) PC

Fence post dimension

Sketch for Foundation

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Detailed Inspection Sheet for: SNOW/ICE CONTROL FACILITIES   Inspection Date: / /   No.

Items	Evaluation/Condition	Comment
1.Effect of facility	(1)Good	
	(2)Not good enough, should be replaced/improved	
2.Defect of facility	(1)No defect, almost perfect	
	(2)Facilities height is not enough	
	(3)Facilities width is not enough	
	(4)Facilities length is not enough	
	(5)Facilities location is not suitable	
	(6)Facilities material is not suitable	
	(7)Facilities design is poor	
	(8)Facilities is not strong enough	
	(9)Other	
3.Snow/Ice condition	(1)Heavy snowfall	
	(2)Strong wind	
	(3)Low temperature	
	(4)Poor visibility due to blizzard	
	(5)Snow drift on road	
	(6)Snow Avalanche	
	(7)Falling down of snow from cutting slope	
	(8)Road surface freezing	
	(9)Other	
4.Maintenance of facility	(1)No maintenance work is needed	
	(2)Sometimes repair is needed	
	(3)Repair is needed almost every year	
	(4)Maintenance work is done by KGM	
	(5)Maintenance work is assigned to contractors	
	(6)Repair cost	

Version 1 8/97

CHAPTER 7 NEW TECHNOLOGY

7.1 General

The developments in laser and infra red technology have enabled equipment to be produced that greatly assists the maintenance engineer in the task of managing the road network by the rapid collection of useful data. The bulk of the equipment relates to pavement surveys of various sorts.

There are a variety of machines available from the very basic to the very sophisticated. Basic systems start with a trailer towed behind a vehicle and move to a purpose made vehicle containing all the equipment needed. The current technology varies between laser and infra-red systems. More expensive vehicles may include video cameras both for recording an inventory of the equipment on the road and also for surface crack monitoring. In some countries they have developed special vehicles and have incorporated additional equipment to carry out the skid resistance and deflection measurements so that they can gather all the information required from a single vehicle. This type of vehicle is generally too expensive for most government run maintenance programmes.

Basic equipment is quite adequate for providing sufficient reliable information to manage the pavement maintenance programme. As more budget becomes available additional equipment may be attached to existing vehicles to provide a wider range of data or more sophisticated technology may be acquired.

More details are provided in Appendix E as an introduction to some of the available technology.

List of Appendices

Appendix A Detailed Inspection Sheets (Masters)
Appendix B Photographic Records
Appendix C Calculation of Standard Deviation
Appendix D Core Sampling
Appendix E New Technology
- E1 The Profilometer
- E2 The High Speed Road Monitor
- E3 Digital Video Systems
- E4 Impulse Radar
- E5 Location Systems
- E6 The Grip Tester

Appendix A

Detailed Inspection Sheets (Masters)

Inspection Sheet

INVENTORY						
Key Identifer	Route	KGM-Division	Survey Category		Date of Survey	
Road General	Sub-Division	Location km from				
	Road Class	Design Speed km/hr	No. of Lanes			
	Carriageway Width m	Shoulder Width m	Sidewalk Width m			
	Pavement (1)Concrete (2)Asphalt (3)Stone Block (4)Stabilized (5)Earth					
	Road Structure (1)Cut (2)Embankment (3)Cut & Embankment					
Site Conditions	Topography (1)Mountainous Terrain (2)Hill Terrain (3)Flat Terrain (4)Soft Soil Area					
	Land Use (1)Built-up Area (2)Residential Area (3)Public Area (4)Industrial Area (5)Farm Land (6)Forrest Land (7)Others ( )					
	Geology					
Traffic Volume in ADT	Passenger Car	Minibus	Bus	Small Truck	Truck	Total

			Box Culvert			Embankment			Slope					Snow & Ice Control Facilities	Retaining Wall			Side Ditch			Shoulder	Gulley			Pavement					km	Pavement					Gulley			Shoulder	Side Ditch			Retaining Wall			Snow & Ice Control Facilities	Slope				
			Collapse	Settlement	Accumulation of Debris	Collapse	Submerge		Erosion	Cracking	Collapse of Protective Wall	Rock Avalance	Landslide	Collapse	Collapse	Settlement	Crack	Collapse	Settlement	Accumulation of Debris	Washing Out	Collapse	Settlement	Accumulation of Debris	wave	Rutting	Potholes	Cracking	Settlement		wave	Rutting	Potholes	Cracking	Settlement	Collapse	Settlement	Accumulation of Debris	Washing Out	Collapse	Settlement	Accumulation of Debris	Collapse	Settlement	Crack	Collapse	Erosion	Cracking	Collapse of Protective Wall	Rock Avalance	Landslide

Appendix B

Photographic Records

PHOTOGRAPH RECORD FORM

Notes from site inspection:-

....
....
....
....

Photograph Number	
Section	
km	
Sub - Division	
Date of Photograph	

Insert the Photograph

Comments on Defect:-

....
....
....
....
....
....
....

Actions Taken:-

....
....
....

Name of Engineer:-

....

Date:-

....

INDEX OF PHOTOGRAPHS

Sub – Division Name	
Sub – Division Number	

Photograph Number	Description of Photograph	Date In

Appendix C

Calculation of Standard Deviation

Calculation of Standard Deviation using Microsoft Excel

The following instructions are to be used to convert road level data taken from the longitudinal roughness survey to a standard deviation value for the section inspected.

The Software needed is Microsoft Excel.

1- Open the file named "Standart Sapma".

2- Insert the levels taken from the section inspected in the column "B" named "siyah kot" for each of the 2 metre points.

3- Having inserted the levels for the total of 50 points, standard deviation value for this particular section can be achieved under the column "F" named "standart sapma".

An example output is shown overleaf.

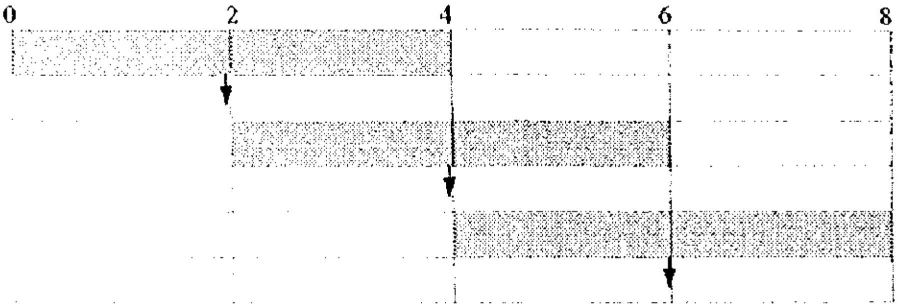
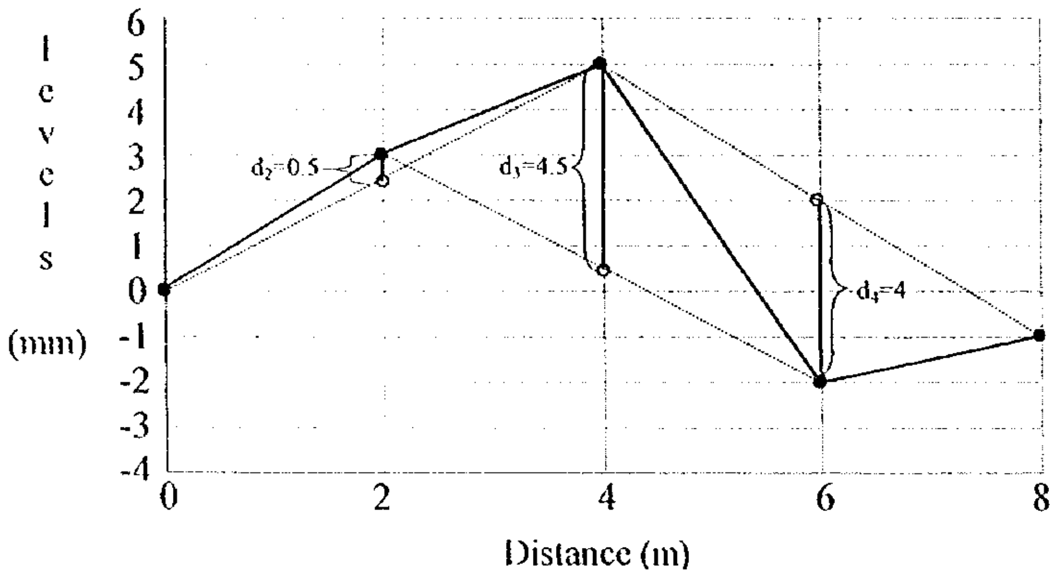


Figure shows that taking the levels from section for each of the 2 metre points by an imaginary vehicle



In the figure given above, levels taken from the section inspected are 0,3,5,-2,-1... In the calculation of longitudinal roughness, it is assumed that vehicle of length of 4m takes levels for each of the 2 metre points as shown in the figure given above. The difference between the mid points of chord of 4 metre and actual levels gives the "d" values. Having calculated all the "d"values for the section inspected, they shall be used to get the standard deviation using the following formula:-

$$\sigma = \sqrt{\{\Sigma(d^2) - ((\Sigma d)^2/n)\}/(n-1)}$$

Where,
σ = the standard deviation
d = measurement taken in mm
n = the number of measurements taken

Note: It is assumed that d_1=0 and d_{50}= d_{49}

All the calculations explained above can be achieved automatically by using the spread sheet in Microsoft Excel provided by the JICA Study Team.

Appendix D

Core Sampling

Core Sampling

The following information is provided to assist in the methods of taking, storing and using core samples.

(i) Core Samples

Core samples should be at least 150mm diameter in order to provide sufficient material for laboratory tests, where these are required. Small diameter coring (25-50mm diameter) can be a cost effective way of obtaining a substantial quantity of visual and thickness data. In this way a longer section can be investigated, although laboratory testing of these cores is impracticable.

(ii) Labelling and Photographs

The core sample should be labelled at the site with the date and location of the sample and returned to the laboratory. A photograph of the problem being investigated should be taken at the site prior to coring. At the laboratory, the core sample should be photographed with a scale strip, with the core identity clearly visible.

(iii) Data to be Recorded

For each core the following items should be recorded:-

- the thickness of each layer
- depth of cracking
- visual condition of each layer
- condition of bonding between layers
- presence of detritus between layers
- the degree of voids and any sign of segregation

(iv) Laboratory Tests

Some or all of the following tests may be requested depending on the nature of the damage being investigated and the results of the visual inspection of the core sample:-

- compositional analysis to provide particle size distribution and binder content.
- percentage refusal density (PRD) compares the achieved level of compaction with the level which it was actually possible to achieve.
- binder penetration.
- density

(v) Reporting Results

A core record should be produced at the laboratory which should contain the following information:-

- core number
- core location
- coring date
- problem under investigation
- layer depths and materials
- aggregate size and type (where known)
- compaction (if carried out)
- comments on items in (vi) above
- summary of core condition

Appendix E

New Technology

E1 The Profilometer
E2 High Speed Road Monitor (HRM)
E3 Digital Video Systems
E4 Impulse Radar
E5 Location Systems
E6 The Grip Tester

E 1 The Profilometer

1 Profilometer is currently available in Turkey. Infra red sensors are mounted on the front of the vehicle, one sensor over each wheel track and one in the centre and it has an onboard computer with monitor and plotter (see photographs). The system records rut depth and longitudinal profile with measurements being taken every 15cm and an average figure being recorded every 100m. The on board computer can generate 3 different pavement condition parameters depending on the settings at the start of the run:-

(i) Ride Number (Rn)
(ii) International Roughness Index (IRI)
(iii) Mays Value

Each index has its merits and often can be converted using correlation formulae to one of the other indices if necessary. In selecting which index to adopt as the norm, consideration should be given to the follow up use of the data, its convertibility, possible use in economic models and use by others.

For each index, values can be established for the new pavement conditions and intervention levels can established based on the pavement design, materials in use and patterns of pavement deterioration which become clearer as more data is recorded.

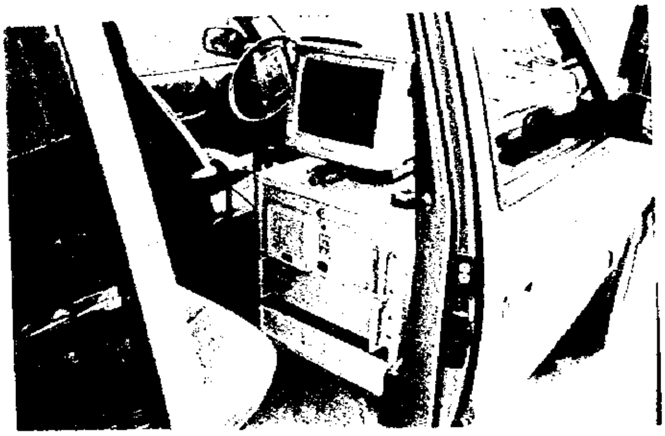
There are 30 000km of State Roads, with only 5 000km being in asphaltic concrete. The Profilometer is currently only used on asphaltic concrete roads because of the high cost of replacement of the sensors if broken by loose aggregate from surface treated roads.

The objective should be to have sufficient equipment available to be able to cover the whole State Road network every 2 years. Cyclic measurement is important as it not only provides information on the present condition but when compared to the previous surveys, the rate of deterioration can be observed. As more State Roads are reconstructed with asphaltic concrete over time, more profilometers will be needed to cover the whole network on a 2 year cycle with a maximum of 4 being required in the long term, allowing for vehicle maintenance, and assuming the whole network is asphaltic concrete.

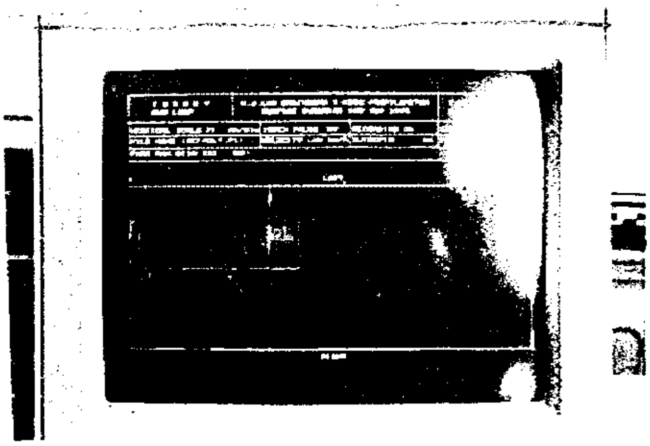
The results of the Profilometer Survey should be provided to each Division as they become available so that where necessary, Detailed Inspections can be planned to investigate the pavement condition, the need for repair works and to determine the most appropriate repair.

Where the equipment is available, this method provides a very quick and consistent method to establish the pavement condition without disruption to traffic as measurements can be taken at normal traffic speeds. Based on the index from the profilometer survey, the maintenance engineer can decide on where to carry out a detailed inspection and this should enable more effective use of detailed inspections by targetting them on those lengths of road most in need of maintenance attention.

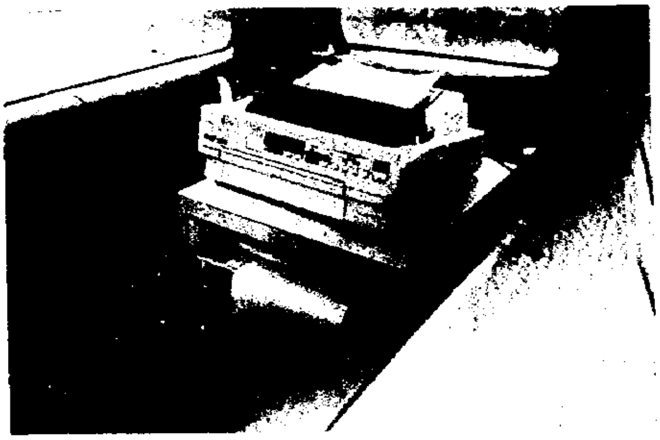
The Profilometer



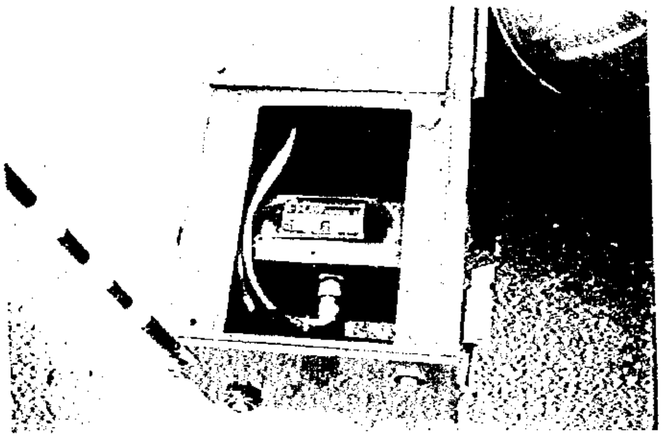
Computer and Monitor



Monitor Showing Data being Recorded



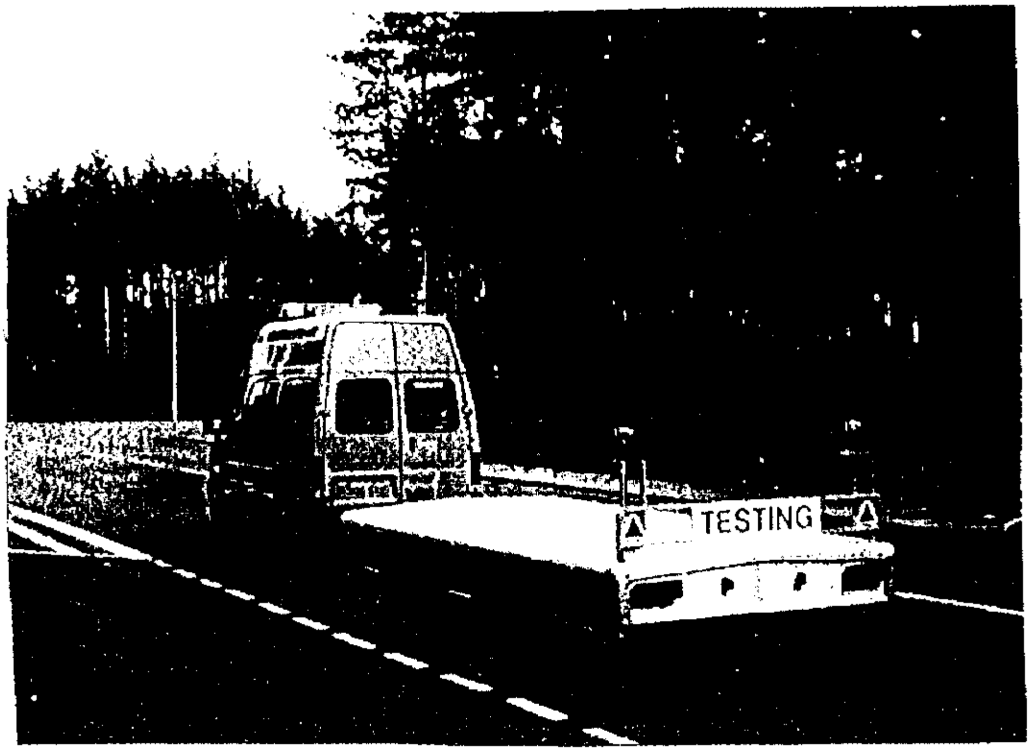
Printer for Hard Copy of Data and Output



Infra Red Sensor Unit mounted on the front of the Vehicle

E2 High Speed Road Monitor (HRM)

The High Speed Road Monitor (HRM) consists of a van and trailer, fitted with laser sensors and other devices, which measures the road surface condition at speeds up to 95 km/hr whilst operating in the normal traffic flow.



High Speed Road Monitor

It records simultaneously, longitudinal profile and macrotexture in the nearside wheelpath, the average rut depth over the traffic lane and the curvature, crossfall and gradient of the road. All data collected is automatically referenced to the highway network.

The HRM trailer is 4.5 metres long and carries 4 laser sensors above the nearside wheelpath. These sensors provide data from which the longitudinal profile and macrotexture of the road surface are derived. A further laser sensor mounted at the mid point of the trailer axle is used in conjunction with the trailer wheels to measure the average rut depth in the nearside and off side wheelpaths. Inclinometers mounted both horizontally and perpendicular to the trailer axle, when corrected for acceleration effects, give crossfall and gradient of the road. A shaft encoder fitted to the nearside trailer wheel provides the distance information. Information from a second encoder on the off side wheel when combined with that from the nearside wheel provides data for calculation of horizontal radius.

The trailer is towed by a van housing all the electronics to operate the system and to store the data.

Using on road markers or bar code markers at the side of the road, the HRM can locate itself to within 1 metre which is essential in order that follow up surveys can be compared with the previous survey.

Longitudinal profile is recorded at 0.1 metre intervals and all other data is recorded as an average over 10 metre lengths.

From the results of a single survey, lengths of road with sub standard surface condition can be identified. Trends in pavement condition can be identified by repeating surveys at regular intervals. Repeat surveys are normally carried out at 2 yearly intervals. HRM surveys are not intended to replace other condition surveys but should enable more effective use to be made of them by targetting them on those lengths of road most in need of maintenance attention.

E3 Digital Video Systems

Digital video systems have now been developed whereby a video of the road surface is taken at normal traffic speeds and the data can be downloaded to a PC using appropriate software to provide a record of the surface condition.

Using this system, laser profiling can be used to determine the transverse profile of the road. Using a line laser, the transverse profile developed by this method is independent of the wheel position and thus the accuracy has improved.

It is not intended that these video systems have a high accuracy since the aim is to quickly identify areas of the network requiring a more detailed investigation. Additionally managers and others can always view the video film rather than visit the site to confirm some item of data.

E4 Impulse Radar

General

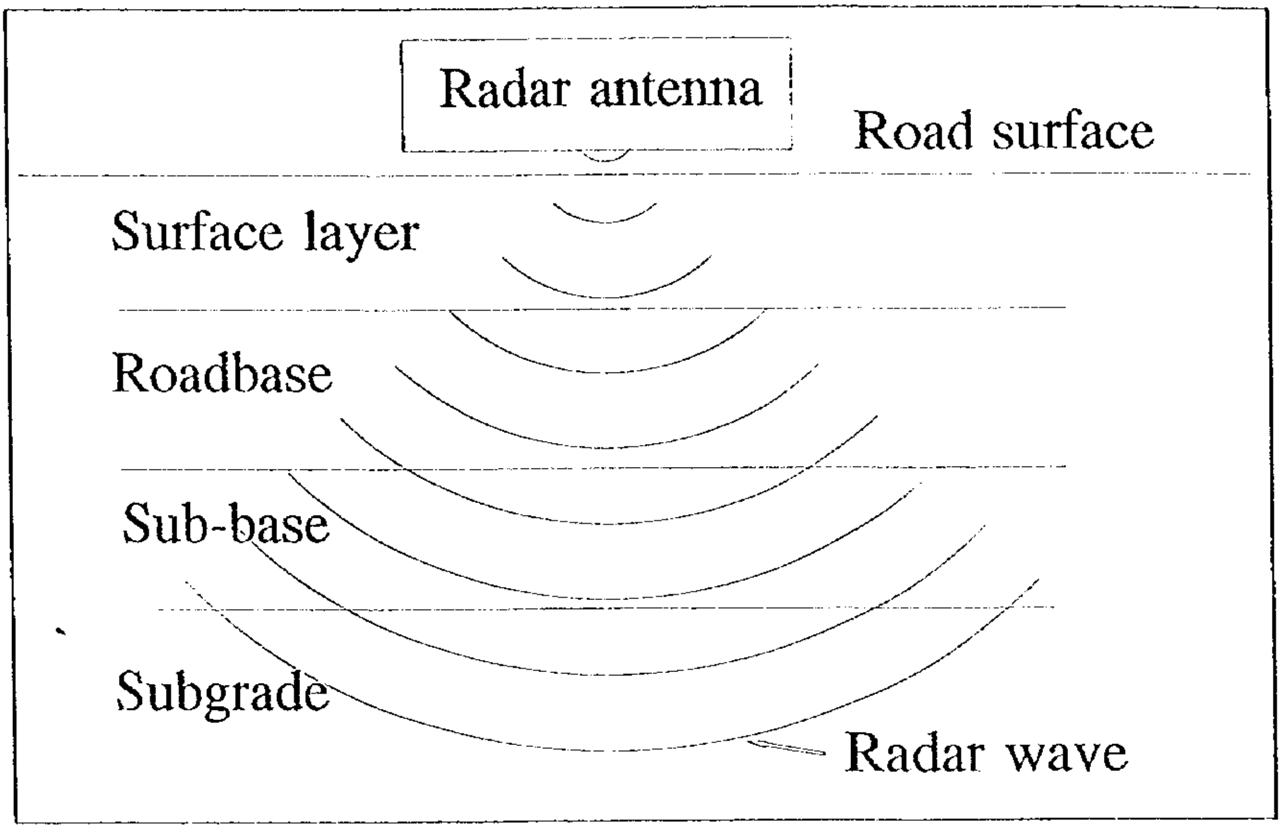
Ground penetrating impulse radar (ground radar) is a non-destructive tool that can be used to obtain information about the construction of a pavement and its internal features. This information can be used to enhance pavement condition information obtained from visual condition and deflection surveys.

Typically ground radar can provide information about pavement layer thickness, changes in construction and defects within the pavement.

This information can be used for checking compliance of new construction, network management and for designing maintenance treatments.

Technical

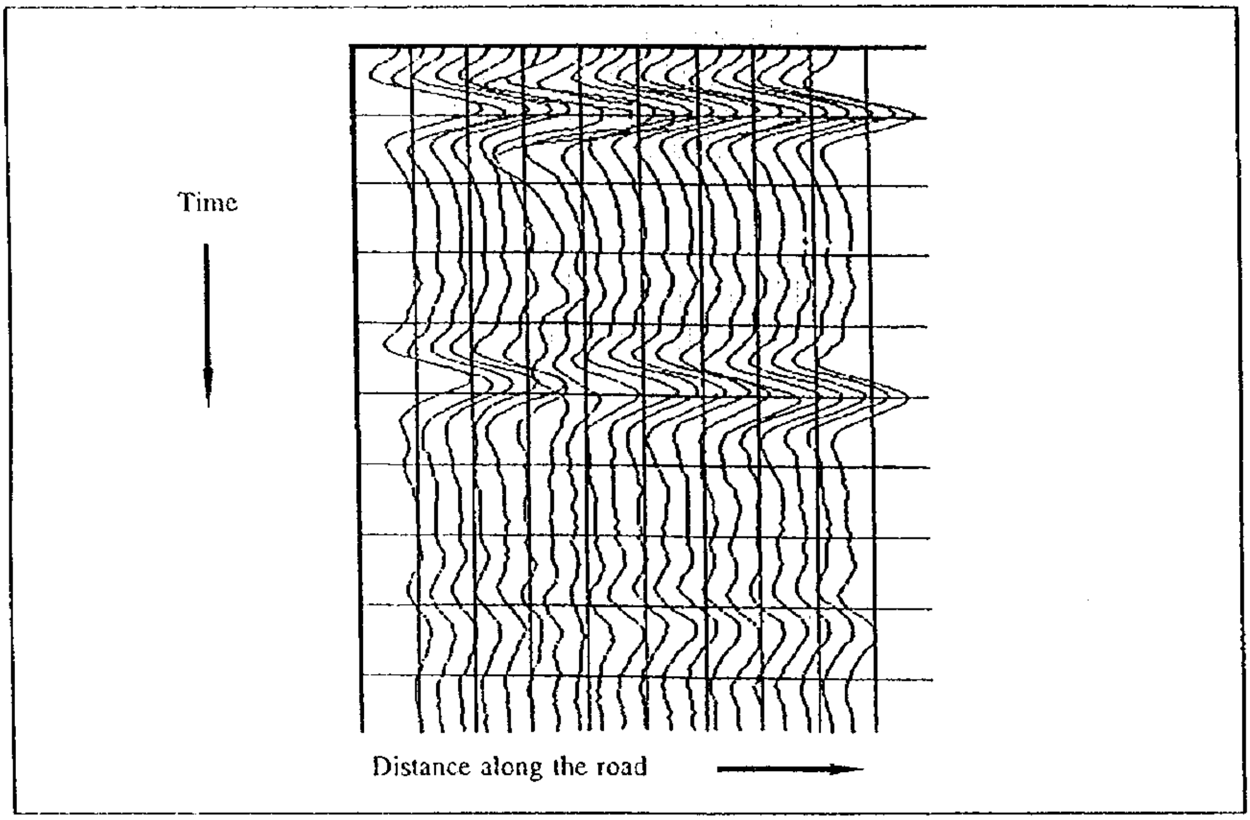
Ground radar operates by transmitting a pulse of electromagnetic radiation from an antenna into a pavement. The electromagnetic radiation penetrates down into the pavement as an energy wave as shown below.



Diagrammatic Representation of a Radar Energy Wave Penetrating a Pavement

As the wave passes through the various pavement layers, its velocity is changed and its strength is attenuated. Part of the signal will be reflected back at the interfaces between different materials such as different pavement layers. It is these reflected signals which contain the information about the interior of the pavement.

By moving the radar along or across the pavement, firing pulses at fixed time intervals, recording and storing the reflected waveforms, a waveform graph representing the pavement structure is built up.



A Typical Waveform Graph.

Interpretation of the pavement structure and features from a waveform graph requires:-

- the time axis to be converted from time into depth measurement
- wavelets to be correctly identified as layer interfaces or other features

Use of Ground Radar

Developments in radar technology are increasing the accuracy and reliability of the data collection such that some information is very reliable and most of the other information is useful in locating problem areas for further investigation when used alongside other data.

Surveys should be carried out in the dry season as water on the surface will affect the radar signal.

Core sample may be used to calibrate the equipment.

The surveys can be used as follows:-

Pavement Feature	Classification of the use of ground radar for pavement assessment A - Sufficiently accurate and reliable for pavement assessment B - Use to confirm pavement condition based on other data C - Use as a guide to pavement condition along with other data	
	Classification	Comment
Bound and unbound layer thicknesses and profiles	A	-
Construction changes	A	-
Cracks	C	Requires special ground radar.
Types of pavement materials	C	Based on assumptions on signal velocity changes and that the pavement materials have identifiable characteristics.

The main advantage to maintenance organisations is that the equipment is readily available and can be used at normal traffic speeds avoiding any traffic disruption. It can be run over the entire network providing a comprehensive record of layer thicknesses which along with other data can be used to identify areas requiring further investigation and information that can be used in calculating the residual life of the pavement or overlay requirements.

Again it is an effective tool to assist the maintenance manager to focus attention on particular locations and so make the best use of the available budget.

E5 Location Systems

All highway data collection systems require accurate location systems to be able to identify the data in relation to the road network. With modern high speed equipment, it is becoming even more important for location systems to be given further consideration such that the equipment can locate itself while in motion and record the location automatically. Repeat surveys are now being used to monitor pavement deterioration and it is essential that data be located at the same point.

Road Studs

Metal road studs have been used but because of winter maintenance work they have often been removed by snow ploughs. These are now being replaced by cored thermoplastic markers. They are located between the wheeltracks of the nearside lane and can be identified by modern equipment using either video data recording equipment or pattern recognition cameras mounted on the vehicle.

Laser Bar-Code Reader

The latest development is to use modern computer technology to identify a bar code mounted at the side of the road either on dedicated marker posts or on existing equipment such as lighting columns. Laser scanning equipment mounted in the vehicle can identify the bar code and hence the location. The advantage of roadside bar coding is that it is not effected by road maintenance works.

E6 The Grip Tester

The Grip Tester is a small compact device used to measure road surface friction. It is simple to use operate and transport.

It is a braked wheel, fixed slip device with drag and load (horizontal and vertical force) continuously monitored with the coefficient of friction calculated and displayed. The data can be collected on a standard PC or laptop.

The Grip Tester can be used at speeds from walking pace (5km/hour) when pushed by a person or up to full traffic speed (120km/hour) when towed behind a suitable vehicle. Because of its size and the speed flexibility, it can be used for full scale pavement surveys or at small scale investigations at road accident sites.

The data collection software incorporates a road referencing recognition system. The output data can be in printed format or incorporated into spreadsheets or a Pavement Management System.

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