HIGHWAYS DEPARTMENT

GUIDANCE NOTES
ON
ROAD TESTING

Research & Development Division

RD/GN/009
September 1989

HIGHWAYS DEPARTMENT

GUIDANCE NOTES

ROAD TESTING

(I) Permeability test

(ii) Sand Patch test

(iii) Skid Resistance test

(iv) Surface Irregularity test; and

(v) Benkelman Beam Deflection Test

Prepared by :

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PERMEABILITY TEST

Prepared by : Research & Development Division

Date : June 1989

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INTRODUCTION

Permeability test on bituminous material is to measure ability of water to pass through the material which is prewetted to remove surface tension effects. The result is taken as an indicator of sufficient continuous voids for the desired field performance. It is usually done on Friction Course.

APPARATUS

1. Metal ring with internal diameter 150 mm and 100 mm internal height.
2. Plasticine
3. Calibrated stop - watch
4. Measuring cylinder having 200 ml. capacity
5. Washing bottle
6. Plastic water container
7. Brushes
8. Towel

PROCEDURE

1. Sweep the road surface ensuring that it is free from loose grit.
2. Wet the road surface to reduce surface tension.
3. Put the 150 mm diameter metal ring onto the road surface.
4. Sealed the ring and road surface with plasticine.

5. Measure 150 ml. of water by means of the measuring cylinder and empty the water into the ring onto the road surface.
6. Record the time for the water to drain off the road surface by means of a calibrated stop - watch.

INTERPRETATION OF RESULTS AND RECORDING OF DATA

1. The time recorded is reported to the nearest second as the permeability of the bituminous material.
2. The time for 150 ml. of water to drain into the Friction Course is less than 30 seconds.
3. At least one set of 10 tests shall be carried out on Friction Course after compaction and before the pavement is opened to traffic.
4. Checking is recommended if any result from the material is found doubtful.

<u>Plate 1</u>

apparatus for permeability test

<u>Plate 2</u>

Wet the road surface to reduce surface tension

<u>Plate 3 & 4</u>

Sealed the 150 mm metal ring and surface with plasticine to prevent water drain out from the edge of the ring

Plate 4

Plate 5

Record the time when the water pour into the ring onto road surface

Plate 6

Record the time when the water drain off road surface

HIGHWAYS DEPARTMENT

MEASUREMENT OF TEXTURE DEPTH BY THE SAND PATCH METHOD

Prepared by : Research and Development Division

Date : June 1989

Measurement of Texture depth by the Sound Patch Method

1. Test Method Reference

   (a) Method 7, BS 598 : Part 3 : 1985
   (b) Road Note 27 Appendix 1

2. Applications

   The road surface texture can be measured by sand patch method. The method is suitable for bituminous surface course and concrete pavement surface with texture depth greater than 0.25 mm. Accurate sand patch testing cannot be carried out when road surface is sticky or wet. For new road surface, it is recommended that sand patch test for compliance checking should be carried out prior to opening to traffic including construction traffic.

3. Apparatus and Material

   1. A pair of dividers capable of measuring radii up to 200 mm.

   2. A 300 mm ruler.

   3. Plastic cylinder of 25 ml volume or preferably a metal cylinder 86 mm internal depth and 19 mm internal diameter.

   4. A flat wooden disc of 64 mm diameter with a hard rubber disc 1.5 mm thick attached to one face. A short spigot or dowel is attached to the reverse face to serve as a handle.

   5. Sand container or for convenience, small plastic bags to hold a measured amount of 25 ml sand.

   6. A soft hand brush.

   7. A straight edge knife.

   8. Sand of a natural dry type, with a rounded particle shape, complying with the grading given in the following table:

Grading of Sand	
BS Test Sieve (mm)	% by Mass passing
0.60	100
0.30	90 to 100
0.15	0 to 15

Grading of Sand for Sand Patch Test

4. Measurement of the average texture depth

a. Measure the surface texture over one or more sections of carriageway lane each 1000 m in length or the complete carriageway lane where this is less than 1000 m.

b. Make measurement on 50 m lane lengths regularly spaced along the section and covering not less than one-third of the section tested.

c. On each 50 m lane length, take 10 individual measurements of the texture depth at 5 m spacing along a diagonal line across the carriageway lane width. Do not take measurements within 300 mm of the longitudinal edge of the carriageway.

d. Where the determination of average texture depth for a section of carriageway lane based on measurements taken over part of the section is less than that specified, extend the measurements to cover the complete length of the section and recalculate the average texture depth.

e. To reduce variability, base determinations of average texture depth on a sufficient number of measurements. For small schemes it may be practicable to carry out measurements over all the wearing course or over alternate 50 m lengths covering 50% of the work. Where this cannot reasonably be done make test measurements over regularly spaced 50 m lengths of carriageway lane covering not less than one third of the surfacing laid in a lane. On larger schemes exceeding a kilometre in length, test selected sections of carriageway lane 1000 m long in the same way. In all cases base the determination of the average texture depth of a test section on not less than six sets of 10 individual measurement. The extent of testing carried out will depend upon the resources available for this work and the standard of compliance with the specification that is achieved. Make at least one determination per lane for every 5 km or less of carriageway surfacing.

f. Where measurements are repeated along different diagonals in the same test section the standard ever (in mm) is 0.4 , n being the number of sets of 10 measurements.

g. If Engineer is confident enough that the average texture depth could lie within a certain range, the no. of sets of 10 individual measurements could be reduced although a minimum of 6 sets is recommended.

5. Individual measurement

a. The surface to be measured must be dry and should first be swept with a soft brush.

b. Fill the cylinder with sand; and, taking care not to compact it by any unnecessary vibration, level the top with a straight edge. (or for convenience, premeasure and put sand into the small plastic bags at 25 ml each prior to going to site)

c. Pour the sand into a heap on the test surface.

d. In windy conditions, use a tyre or a 3-sided enclosure to surround the sand such that sand is not easily to be drifted away.

e. Spread the sand over the surface with use of the wooden disc with its face kept flat, in a circular motion so that the sand is spread into a circular patch with the surface depression filled to the level of the peaks. Measure either the radii of the dividers on the sand patch or practically the diameters at every 45° and calculate the mean of the 4 individual diameters (d) to nearest 1 mm.

6. Report Results

a. Sketch should be prepared.

b. Calculate the texture depth of each individual test to the nearest 0.01 mm from the following formula;

c. Texture depth (in mm) = 31000

d. Determine and report the average texture depth for each section of carriageway lane tested and the average of each set of 10 individual measurements.

e. A standard form for recording data is at Appendix.

HIGHWAYS DEPARTMENT
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TEXTURE DEPTH MEASUREMENT

Material Type :

Location : Laid Date :

Volume of Sand Used : Testing Date :

Chainage	Sample No.	Diameter of Sand Patch (mm)					Texture depth (mm)		Remarks
		D1	D2	D3	D4	Mean	Individ	Mean	

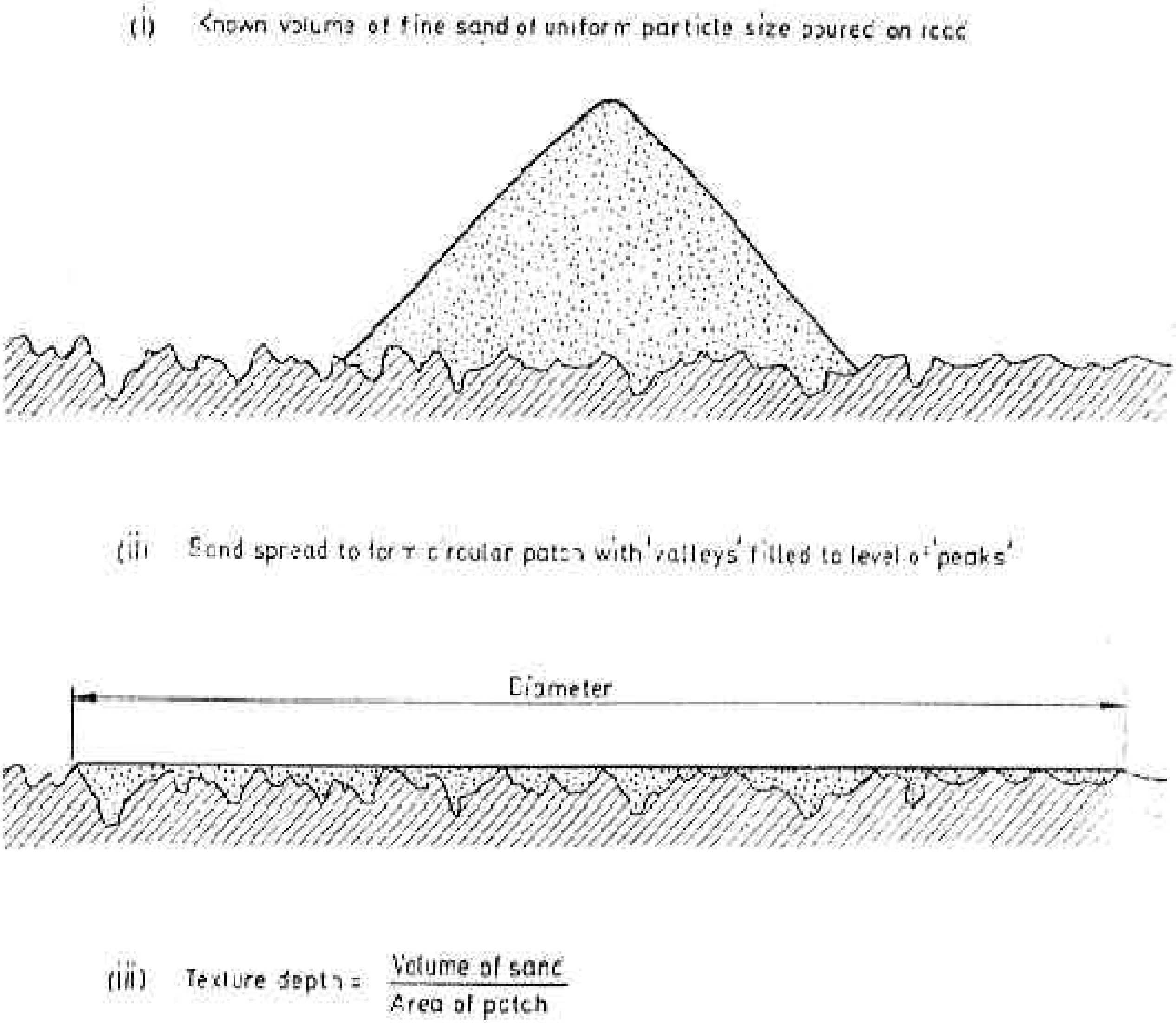

FIG. 2. Sand-patch method of measuring texture depth

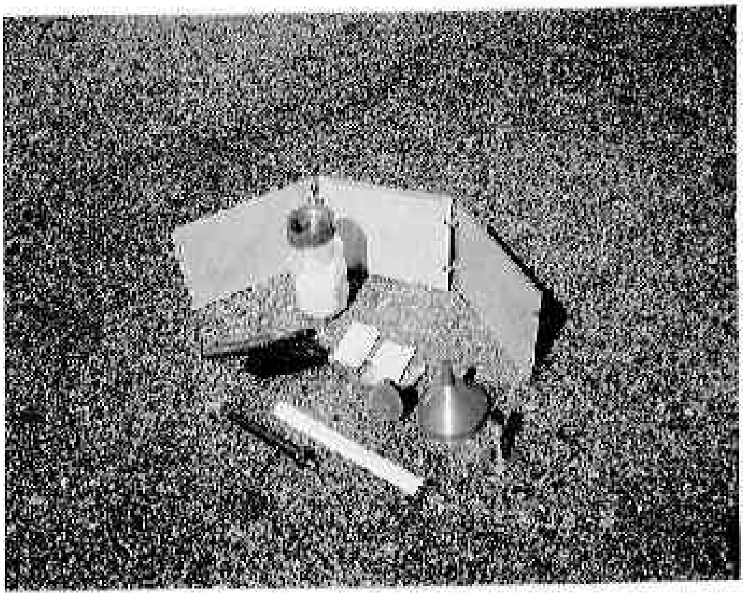

Plate 1

apparatus for measuring texture depth by sand patch method

Plate 2

Sand is measured to exact volume and pour into a heap on the tested surface

Plate 3

Sand is spread into a circulare path by means of a wooden disc with rubber disc kept flat

<u>Plate 4</u>

Diameter is measured at every 45 °C by a 300 mm ruler

HIGHWAYS DEPARTMENT

SKID RESISTANCE TEST

Prepared by : Research and Development Division

Date : June 1989

Skid Resistance Test - Portable Pendulum Tester

1. Test Method Reference

   (i) Road Note 27

   (ii) ASTM E 303-83

2. Applications

   The resistance of wet road surfaces to skidding can be checked by means of a Portable Skid-resistance Tester (Portable Pendulum Tester). This apparatus developed at the Road Research Laboratory is used to measure the frictional resistance between a rubber slider (mounted on the end of a pendulum arm) and the road surface. This method provides a measure of frictional property, microtexture of surfaces, either in the filed or in the laboratory.

   The quantity measured with the portable tester has been termed "Skid-resistance" and this correlates with the performance of a vehicle with patterned types braking with locked wheels on a wet road at 50 km/h.

3. Setting the tester

   a. Set the base level by means of the spirit level and the three levelling screws on the base-frame.

   b. Raise the head so that the pendulum arm swings freely. Movement of the head of the tester, carrying the swinging arm, graduated scale, pointer and release mechanism is controlled by a rack and pinion on the rear of the verticle column. After unclamping the locking knob A at the rear of the column, the head may be raised or lowered by turning either of knobs B. When the required height is obtained the head unit must be locked in position by clamping the locking knob A.

   c. Check the zero setting. This is done by first raising the swinging arm to horizontal release position on the right-hand side of apparatus and the swinging arm is automatically locked in the release catch. The pointer is then brought round to it stop in line with pendulum arm. Release the pendulum arm by pressing button C. The pendulum arm on its return swing and note the pointer reading. Return the pendulum arm to the release position and locked. Correct the zero setting as necessary by adjustment of the friction ring E. Ring E are screwed up by a little more tightly if the pointer has swung past zero position. If it has not reached zero the rings should be unscrewed a little.

   d. With the pendulum arm free, and hanging vertically, place the spacer which will be found attached to a chain on the base of the verticle column, under the lifting - handle setting - screw to raise the slider. Lower the head of the tester using knobs

A and B so that the slider just touches the road surface and clamp in position with knob A. Remove the spacer.

e. Check the sliding length of the rubber slider. This can be achieved by raising slider to one side using lifting handle and gently lowering the pendulum arm until the slider just touches the surface first on one side. Then slowly lower until slider touches the surface on the other side of the verticle. The sliding length is the distance between the two points where the sliding edge of the rubber touches the test surface. The sliding length should be between 125 and 127 mm when the apparatus is correctly set.

f. Place pendulum arm in its release position. The apparatus is now set ready for testing.

4. Testing procedure

a. Inspect the road and choose the section to be tested.

b. Set the tester on the road surface in the track chosen so that the slider swings in the direction of the traffic. On surface bearing a regular pattern, such as ridged or brushed concrete, tests should be made with the slider operating at 80° to the ridges.

c. Sweep the road surface ensuring it is free from loose grit.

d. We the road surface and slider.

e. Bring the pointer round to its stop. Release the pendulum arm by pressing button C and catch it on the return swing before the slider strikes the road surface. Reading should be discarded if the slider is not wetted as well as the road surface.

f. Return the arm and pointer to the release position and keep the slider clear of the road surface in this operation by means of lifting handle.

g. Spread water over the contact area with hand or a brush and repeat swings.

h. The contact area and the slider must be wet between each swing.

i. Record the mean of five successive readings provided they do not differ by more than three units. If the range is greater than three units, repeat swings until three successive readings are constant. Record this value.

j. Take the mean at each of five locations in the test track (usually at the nearside wheel-track) spaced at approximately 5 - 10 m intervals. This mean reading gives a representative value of the skidding resistance of that road.

k. When testing completed at each location, recheck the zero adjustment and sliding length adjustment of the equipmenet.

l. Measure the temperature of water lying on the road surface immediately after test for Correction.

5. Interpretation of results and recording of data

The skidding resistance of wet roads varies with time. The magnitude of the variation depends on (a) road and traffic conditions (b) road surface characteristies, and (c) the weather.

The effect of temperature on rubber resilience exerts a perceptrible influence in all skidding resistance measurements, showing a fall in skidding resistance as the temperture rises. In addition, the magnitude of the variation of skidding resistance with temperature varies considerably from road to road because of the changes in road surface texture. An average temperature correction evaluted for a range of surface textures given in Fig. 4.

From the gradh, the correction for skid-resistance values is importance for tests made at temperatures below 10°C and its main use is to give a more accurate assessment of the skidding resistance which the road is likely to offer to the tyres of vehicles since they are likely to be running at temperature rather higher than that of the slider rubber on the portable tester.

A standard from for recording data is attached. A sketch plan showing the tested section should also be included in the report.

6. Maintenance of tester

1. Sliders should be renewed when the sliding edge becomes burred or rounded. All new sliders should be roughened before use by swinging several times over a piece of dry road.

2. Slider must be kept clean free from oil and grease.

3. Check to ensure the slider is free to ture on its spindle.

4. For ease of operation, all screws, racks and guides should be kept oiled.

5. Calibration of all testers should be done at least once a year and all spare sliders (used or unused) should be checked for resilience at the same time.

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CONTRACT NO.________

Skid-resistance test results on wet surface

Material :

Date tested :

Location :

Laid Date :

Date	Section	Test track (distance from kerb) m	Surface texture (mm)	Temperature of water on road (°C)	Skid-resistance						Remarks
					Mean readings at individual location					Mean	
					1	2	3	4	5		

Plate 1

Portable skid - resistance tester

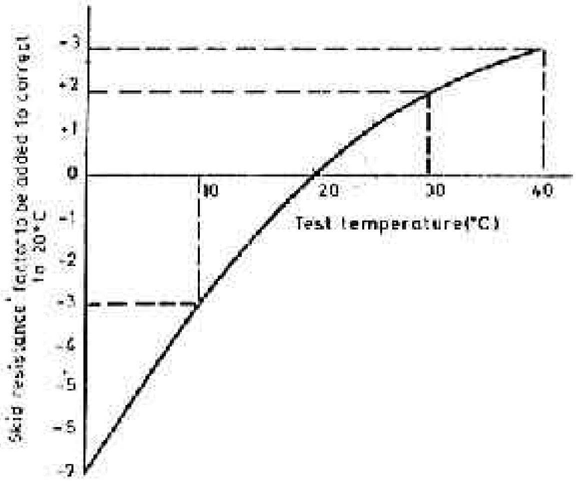


FIG. 1. Suggested temperature corrections for 'skid-resistance' values to allow for changes in resilience of the slider rubber

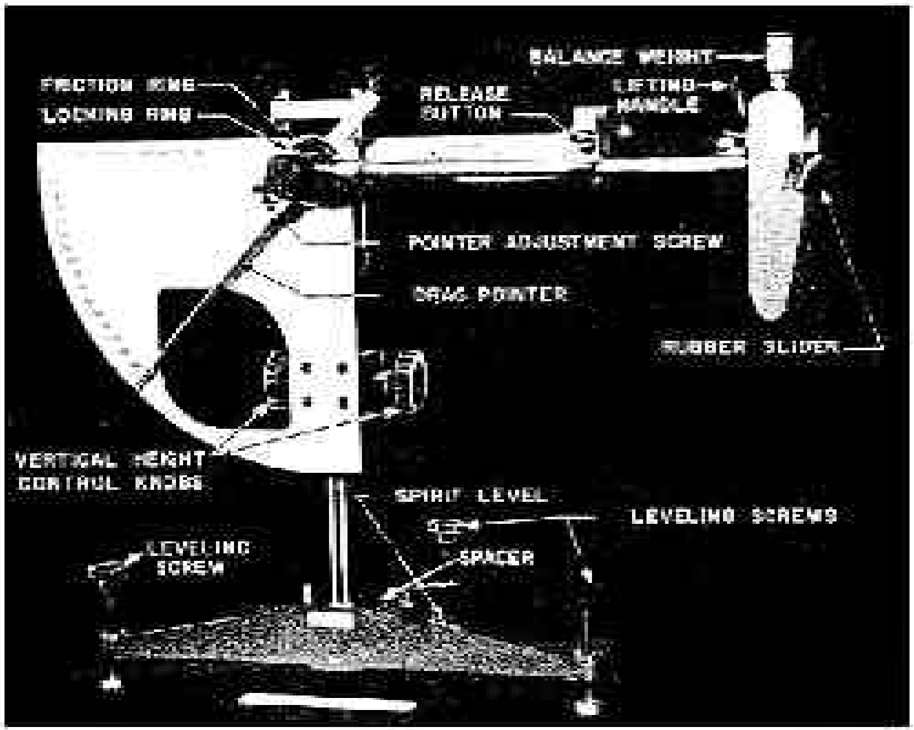


FIG. 1 British Pendulum Tester

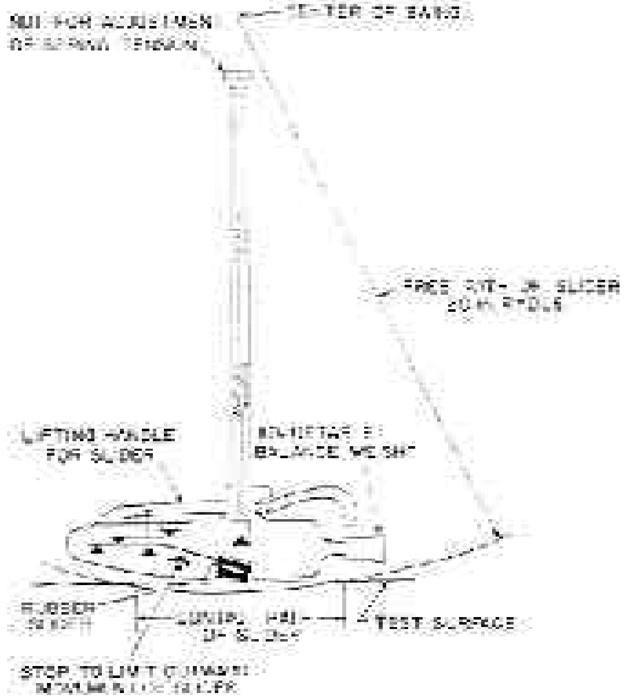


FIG. 2 Schematic Drawing of Pendulum Showing Spring and Lever Arrangement

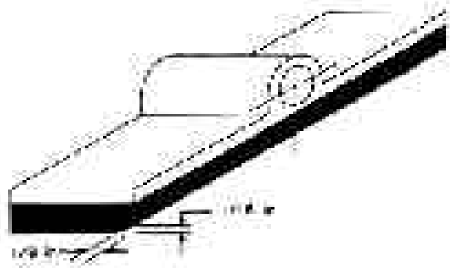


FIG. 3 Slider Assembly Illustrating the Maximum Wear on Striking Edge

HIGHWAYS DEPARTMENT

<u>SURFACE IRREGULARITIES TEST</u>

Using a 3 m long Rolling Straightedge.

Prepared by : Research & Development Division

Date : July 1989

Surface Regularity Test - Rolling Straightedge Method

1. Test Method Reference

   a. Department of Transport. Specification for Road and Bridge Works. London, 1976 (H M Stationery Office)

   b. Rolling Straightedge Manufacturer. Leonard Farnell and Company Ltd., North Mymms, Hatfield, Herts.

2. Applications

   This test utilizes a multi-wheeled rolling straightedge designed by the Transport and Road Research Laboratory in the United Kingdom. The rolling straightedge approximates to a 3 m straightedge sliding along the road surface and consists of a rigid frame supported on 40 rubber-tyred wheels of 127 mm diameter arranged in two parallel rows, 114 m apart. At the mid-point of the 3 m length, a sensing wheel, mounted between the two parallel rows of supporting wheels, is free to move such that it detects depressions, but not bumps, in the road surface.

   Vertical movements of this wheel are transmitted to two similar pointers on graduated scales on the instrument head. Rotation of the central sensing wheel drives a distance meter. In use, the straightedge is pushed by hand along the road surface at a slow walking pace (approximately 1-2 km/h, depending on the degree of irregularity) and the numbers of irregularities, their size and their distance from the starting point are noted. To avoid the need for continuous observation, a bell or buzzer can be set to operate when a pre-selected size of irregularity is exceeded.

   The rolling straightedge made in three separate parts for ease of transport can be quickly assembled and dismantled. The three sections, constructed of glass fibre and steel, being designed to clamp together so that the overall alignment of the wheels remains unaffected.

3. On-site checking on rolling straightedge

   a. Calibration check should be carried out before the start of each day's testing or "on-site" check after a long distant transportation.

   b. Examine all the supporting wheels. Ensure that the surfaces of the wheels are free from mud, stones and other deposits so that each wheel is free to rotate on its shaft.

   c. Check if the battery, the electric bell, sensing wheel, the distance meter is functioning correctly. Also inspect all locking clamps in each section.

e. Calibrate and adjust the pointer of central sensing wheel (as user's calibration) before testing. Pre-set the warning bell, on the rolling straightedge at an irregularity reading as appropriate.

4. <u>Procedure</u>

a. Sweep the road ahead of the machine along the line of the traverse.

b. Start the traverse at a known chainage and record on data sheet. Remember to set the distance meter to zero.

c. Keep the rolling straight edge parallel to centre line of the carriageway. To assist in this a measuring stick is useful. This should be appropriate length, relative to the carriageway edge and suitable fixed to the straightedge.

d. When road junctions are within the traverse length the irregularities recorded within 20 m either side of the junction shall not be included. This distance shall be measured from kerb line to the nearest wheels of the straightedge. However, note from the distance meter the distance that excluded.

e. Push the rolling straightedge at a slow walking pace (approximately 1-2 km/h).

f. When an irregularity greater than 3 mm is recorded, move the straightedge slowly backwards and forwards to locate the position of maximum depression.

g. At this point, note the reading on the distance meter and mark the road with chalk and also the value of maximum depression and the extent of the depression greater than 3 mm.

h. Record the distance reading and tick the appropriate column of the record sheet. Note that an irregularity exceeding 6 mm (or 9/10 mm) will almost invariably be immediately preceeded and followed by an irregularity exceeding 3 mm. In such case, this is to be counted a one 6 mm (or 9/10 mm) irregularity - not a multiple. Avoid double counting.

i. Note the presence of any structural features which influence the recorded values e.g. manholes.

j. When the traverse is completed rewalk it's length checking that the information is correctly recorded and make any partinent notes.

k. A team of 4 persons is recommended.

i.e. i) operator ii) recorder iii) sweeper iv) marker

5. <u>User's Calibration</u>

In addition to the accurate calibration carried out by the manufacturer, a simple "on-site" check can be made by user as follows:-
Place 2 strips of accurately finished timber (e.g. marine ply), approximately 200 mm wide x 3 mm thick x 1.5 m in length, longitudinally on a flat and even surface such as an office or laboratory floor, or a bench top. Leave a gap of about 150 mm between the ends of the strips as shown in Fig. 1.

Stand the assembled straightedge on the timber strips so that the central sensing wheel can be lowered into the gap of 3 mm depth. Check the position of the pointer relative to the 3 mm mark on the graduated scale. By adding further 3 mm strips, the 6 mm and 9 mm positions can be checked in a similar manner. Alternatively, by using 2 pairs of the 3 mm thickness and 1 pair of 4 mm thickness (this being a standard size and readily obtainable) it will be possible to check the readings for 3, 4, 6, 7 and 10 mm depressions. The 4, 7 and 10 mm depressions are the most important as these are the tolerance referred to in the specification. It would also be advisable to check the zero position by the butting the ends of 2 strips together.

It is recommended that this simple calibration check be carried out before the start of each day's testing. The equipment should be expected to give the correct reading to within approximately 0.5 mm. If it fails to do so, it should be returned to the manufacturer for service and accurate recalibration.

6. Precaution

The equipment should be dismantled whilst being transported in order to avoid damage.

HIGHWAYS DEPARTMENT

__________REGION

Surface Irregularities Test - by 3 m long static straightedge

Contract No. : Date tested :

Carriageway : Chainage :

Location : Tested by :

	Straightedge Readings Across Lane (mm)													
Location	0.2m	0.4m	0.6m	0.8m	1.0m	1.2m	1.4m	1.6m	1.8m	2.0m	2.2m	2.4m	2.6m	2.8m

HIGHWAYS DEPARTMENT
RESEARCH AND DEVELOPMENT DIVISION

Surface Irregularities Test - By 3 m long rolling straightedge

Contract No. :

Date tested :

Location :

Chainage :

Material :

Traverse length :

Road chainage (metre)	Meter reading		Exceeding - irregularities			Remarks
	from	to	3 mm	6 mm	10 mm	

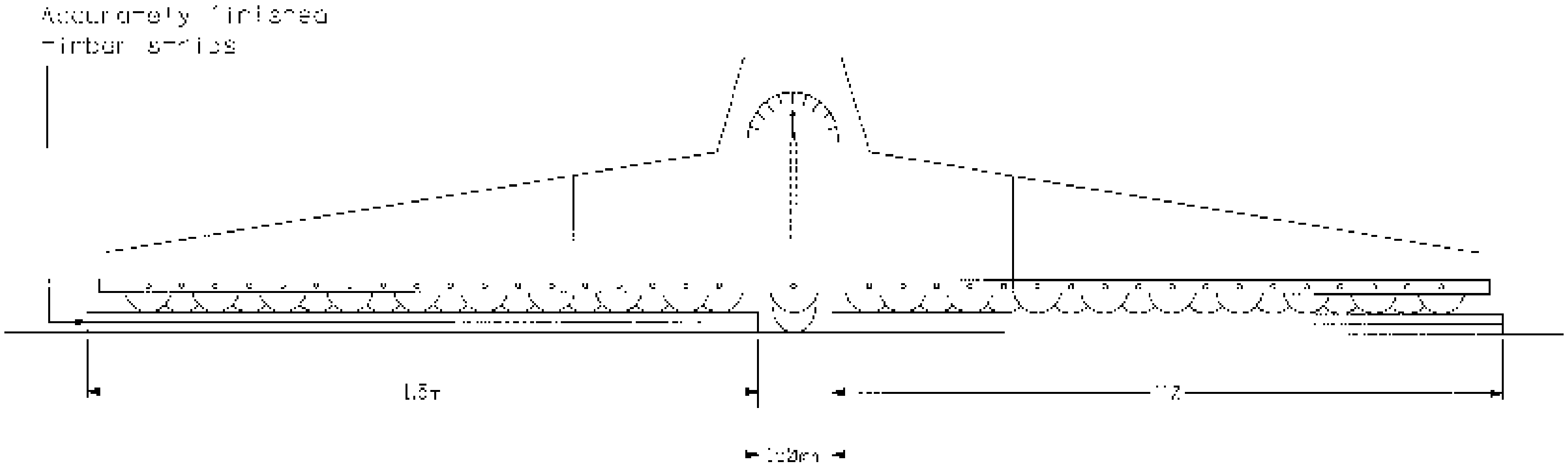


Fig. 1 USER'S CALIBRATION CHECK OF THE ROLLING STRAIGHTEDGE

HIGHWAYS DEPARTMENT

BENKELMAN BEAM TEST

ROAD DEFLECTION TEST

Prepared by : Research and Development Division

Date : June 1989

Benkelman Beam Test

1. Test method reference

TRRL Report 833, 834 and 835
RCA Technical Bulletin No. 33 March 1986

2. Application

Deflection measurements may be obtained by means of Benkelman Beams, Deflectograph, or Falling Weight Deflectometer. These devices use the similar principle of operation, but results obtained may not be identical in all cases. If devices other than Benekelman Beam is used, conversion from any given measured deflection value to the equivalent Deflection Beam deflection measured at a pavement temperature of 20°C, 40 mm below the surface is necessary.

Deflection Beam measurement is a very good measurement of the structural response of a pavement to a given axle loading moving at creep speed. Deflection parameters are used for the following purposes :

(a) as a guide to the strength and stiffness of a pavement,

(b) as a guide to the future performance of a pavement,

(c) as a means of determining how much strengthening/stiffening of a pavement is needed to satisfy specified design criteria,

(d) to monitor change in the structural performance of a pavement resulting from variations in the environment or specific maintenance activities,

(e) to locate deficiencies, and assist in determination of their causes,

(f) to assess the uniformity of pavement strength during or shortly after construction, and

(g) to monitor long term pavement performance, as one of the inputs which may be used to describe pavement condition.

3. Description of Benkelman Beam Equipment

The Benkelman Beam shown in attached sketch has a movable beam attached through a fulcrum to a fixed base which rests on the pavement surface. The beam apparatus is placed on the road surface with the extreme end or tip of the beam resting and remaining on the pavement surface at the point where the deflection is to be measured. Movement of the tip of the beam is measured by a dial gauge, which is in contact with the other end of the beam. The fulcrum of the beam is at a point one third of the distance between the tip and dial gauge. This causes the movement recorded by the dial gauge to be one half of the actual pavement deflection.

Since pavement deflection depends on wheel loading, tyre characteristics, and wheel and axle configuration, these factors are specified in the standard test. The test vehicle is suitably ballasted to impose a load on the rear axle of 6350 kg and is fitted with dual wheels.

4. Details of beams

Essentially the device consists of :

a. Aluminum base section

b. Aluminum probe beam - 2 sections

c. Battery operated buzzer

d. Adjustable rear support

e. Dial gauge (25 mm travelling distance, 0.01 mm graduation) mounted with a 45° mirror

f. Spirit level

5. Details of test vehicle

Characteristic	Satisfactory range
Rear axle load	6350 kg ± 10%
Dual rear wheel load	3175 kg ± 105
Front axle load	between 2300 and 3300 kg
Wheel base	nominally 3.85 m
Tyre size	8.25 x 20) preferred 7.25 x 20) 9.00 x 20 acceptable
Tyre pressure	590 kN/m° (85 p.s.i.)
Minimum gap between walls of twin rear wheels	not less than 20-30 mm
Gap between contact area of twin rear wheels	90 to 140 mm
Moving speed	5 m in 10 ± 1 sec.

6. Procedure

a. Test points are marked in the inner and outer wheel paths of the selected section of road (looking in the direction of traffic flow, wheelpath to the left is the nearside wheelpath). As a guide the table below may be adopted for the nearside wheel location.

Lane width	Distance from kerb or lane edge
3.7 m	0.9 m
3.4 m	0.8 m
3.0 m	0.6 m
2.7 m or less	0.4 m

For the offside wheel location, it should be 1.9m apart from the nearside wheel location.

b. The distance between test points depends mainly on the purpose of the survey and the visual condition of the road. For generally sound length of road, the table below could be used a guide for spacing between transverse section.

Surveyed length of carriageway	Spacing % Transverse Test Section
< 1/2 km	20 m
½ to 1 km	25 m
1 to 2 km	50 m
> 2 km	

Where the road shows visual signs of deterioration or the deflection measurements are sufficiently high over variable to suggest that structural deterioration is likely, the test points should be placed more closely together, a spacing of 12 m is recommended.

c. A clearly identifiable datum should be adopted for the chainage.

d. Lanes are numbered from left to right, looking in the direction of traffic flow with lane 1 being the slow lane.

e. The starting point for the lorry in each test is marked by a line drawn at right angles to the kerb at a distance of 1.3 m behind each test point. The lorry is reversed parallel with the kerb so that the gap between either pair of dual wheels passes over the appropriate test point, and the rear wheels come to rest on the starting line. The beam (or beams when 2 beams are used) in the locked position is passed through the gap in the dual rear wheels and tip is placed on the test point. The frame of the Deflection Beam is then lowered on to the road.

f. By looking through the gap between the dual rear wheels the operator can ensure that the beam is lying in the centre of the gap, parallel with the direction of the lorry's forward movement, and that the tip is approximately in line with the centre of the front tyre when the front wheels of the lorry are pointing straight ahead. The same procedure is used for testing in the inner wheel patch if only 1 beam is used.

g. When the beam is in position the lock is released, and with the vibrator running, the dial gauge reading is set to zero by rotating the scale.

h. At a signal from the operator, the vehicle is driven forward at creep speed to a position where the rear wheels are at least 3 m beyond the test point.

i. Vibration of the beam is continued until the lorry has reached a point 3 m from the beam tip and during this time, the maximum and final readings of the dial gauge are taken.

j. The magnitude of the pavement deflection is obtained by adding the maximum reading to the difference between the maximum and final readings. (as the ratio of beam arms is 2 : 1) or double the former calculated value (as the ratio of beam arm is 4:1)

k. Two measurements are normally made at each test point and the mean result obtained. For deflections greater than 25×10^{-2} mm the readings should not differ by more than 5% of the mean value; for smaller value, the difference should not exceed 10%.

l. Raise the gauge, lock the beam before bring it forward to next point. Repeat the same procedure at each test points.

m. Pavement temperature at the depth of 40 mm below road level is measured by inserting a thermometer into two holes containing glycerol at each location.

7. Effect of Temperature on Deflection

Variation in temperature result in significant changes in the stiffness of bituminous material and therefore in the strength and stiffness of pavement layers. The stiffness may be reduced by a factor of between 5 and 10 (depending on the duration of the applied load) as its temperature is increased from 10°C to 30°C. The temperature of bituminous surfacing must therefore be recorded during deflection testing so that appropriate adjustments can be made during the analysis and design phases.

8. Effect of Moisture on Deflection

In other countries a slight increase in pavement deflection has been noted during the spring to early summer months, possibly resulting from higher moisture contents under the pavement at these times. However, the seasonal effect of moisture is not a straight forward rainfall/deflection relationship. It is affected by many factors including surface infiltration, permeability of the pavement layers and subgrade, evaporation and drainage conditions at the site. The evaporation and drainage factors limit the quantity of water available to infiltrate the pavement and the subgrade, whilst permeability influences the rate of infiltration and consequently the time lag between the incidence of rain and its effect on deflection. The effect has yet to be quantified.

9. <u>Other associated measurements</u>

In association with the Benkelman Beam Deflection test, the depth of each pavement layer and the CBR and moisture content of subgrade should also be recorded. The location and frequency for these other tests should be decided by Engineer.

10. <u>Precautions</u>

Inaccurate measurements are normally associated with under-registration. Therefore, if a low reading is followed by two high values which agree within the limits stated, the low reading can be ignored. Similarly, if a high reading is followed by two low readings which agree, a fourth reading must be taken to verify the two low readings, but if the fourth reading agrees with the high value, the two low readings are ignored. If large differences are recorded on the same test point, these can be caused by the lorry wheels touching the beam or by friction in the beam pivot or dial-gauge. When these points have been investigated and if necessary corrected, further readings are taken. If satisfactory agreement cannot be obtained, the mean of five measurements should be taken and the variability noted.

During sunny weather the beam may pass from shade into sunshine as the vehicle moves away from the test point; this can cause sufficient differential thermal expansion within the beam to give significant errors in the measured deflection, particularly on stiff pavements. Under these conditions, use of the sunshade provided with the Deflection Beam and taking the final deflection reading immediately the lorry is 3 m beyond the test point reduce the error.

11. <u>Record of Measurement</u>

A standard form is attached for record purpose.

12. <u>Calibration of Equipment</u>

The beam and the dial gauge should be calibrated annually.

HIGHWAYS DEPARTMENT

________________________________ REGION

Form for recording deflection measurements with Benkelman Beam

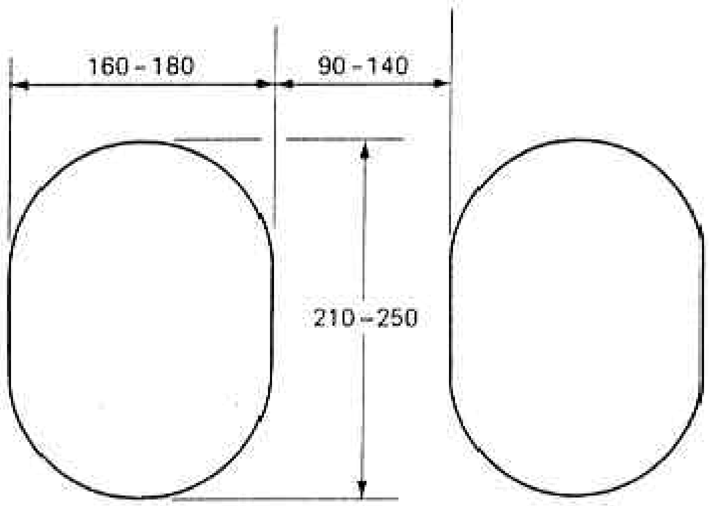
Beam ratio :

Material Type : Layer 1 : Date Tested :

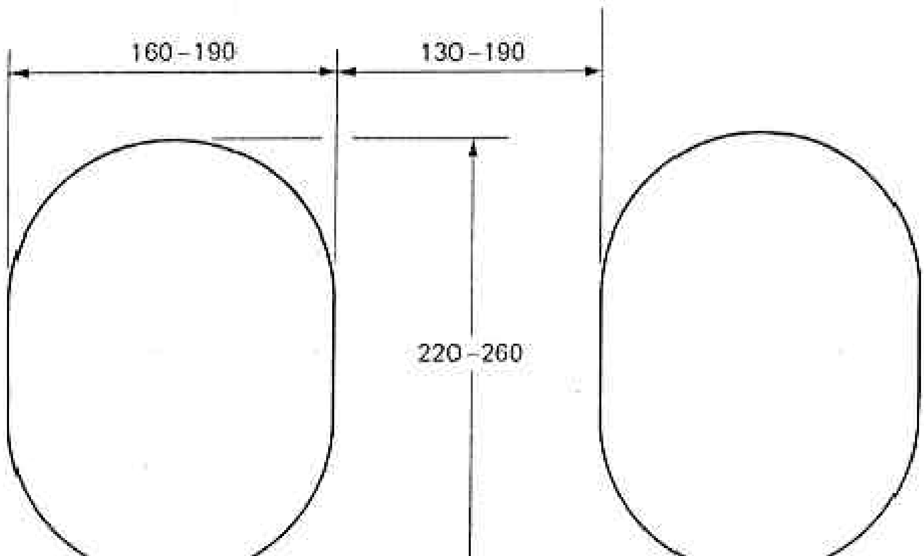
Layer 2 :

Location : Layer 3 : Site No. :

Change	Road temp. °C (40mm below)	Nearside wheel path						Offside wheel path					
		Wheel load (kg)	Deflection x 10^{-2} mm			Rut depth (mm)	Visual road surface condition	Wheel load (kg)	Deflection x 10^{-2} mm			Rut depth (mm)	Visual road surface condition
			Max. (1)	Final (2)	(1) + [(1) - (2)]				Max. (1)	Final (2)	(1) + [(1) - (2)]		



DEFLECTION BEAM TYRE PRINT



DEFLECTOGRAPH TYRE PRINT

(Dimensions in mm)

Fig. 2 RANGE OF TYRE CONTACT DIMENSIONS OF THE DEFLECTION BEAM AND DEFLECTOGRAPH

Dimensions	Metres	Feet	Dimensions	Metres	Feet
a	2.44	8	d	0.92	3
b	1.22	4	e	0.61	2
c	0.30	1	f	1.30	4.25

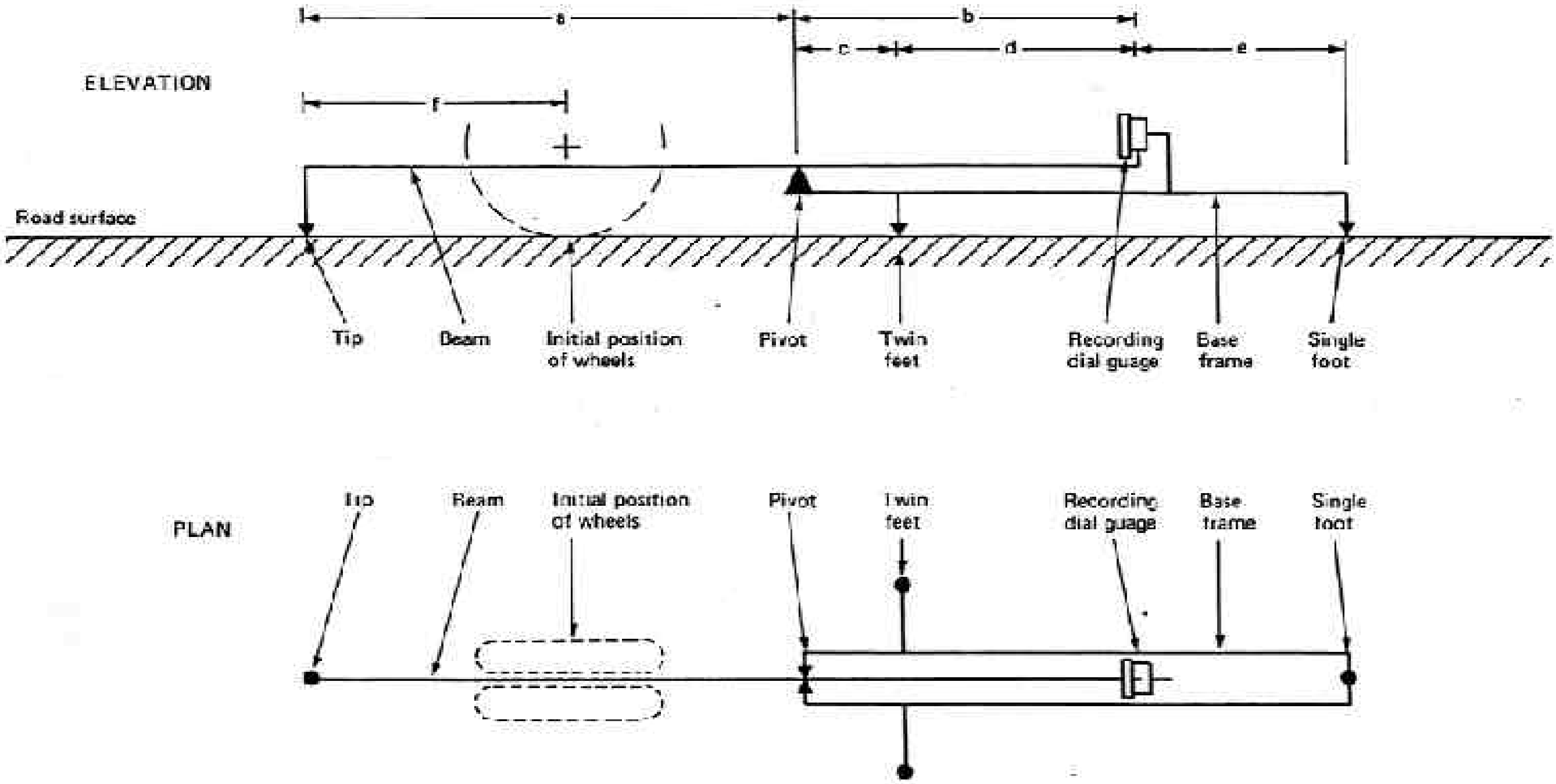
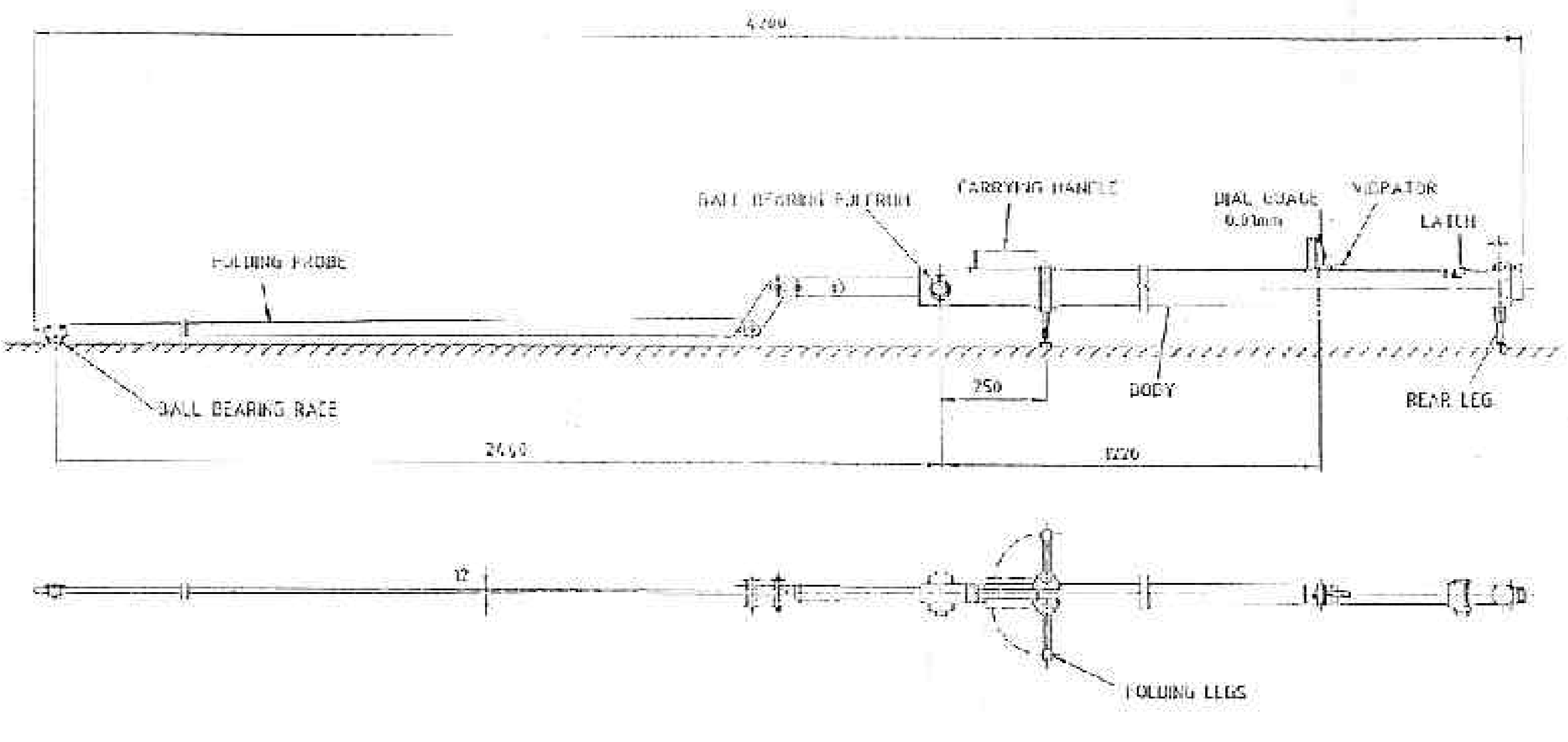


Fig. 1 DIAGRAMMATIC REPRESENTATION OF THE DEFLECTION BEAM



(ALUMINIUM CONSTRUCTION)

DIMENSIONS IN MILLIMETRES

BENKELMAN BEAM

BENKELMAN BEAM

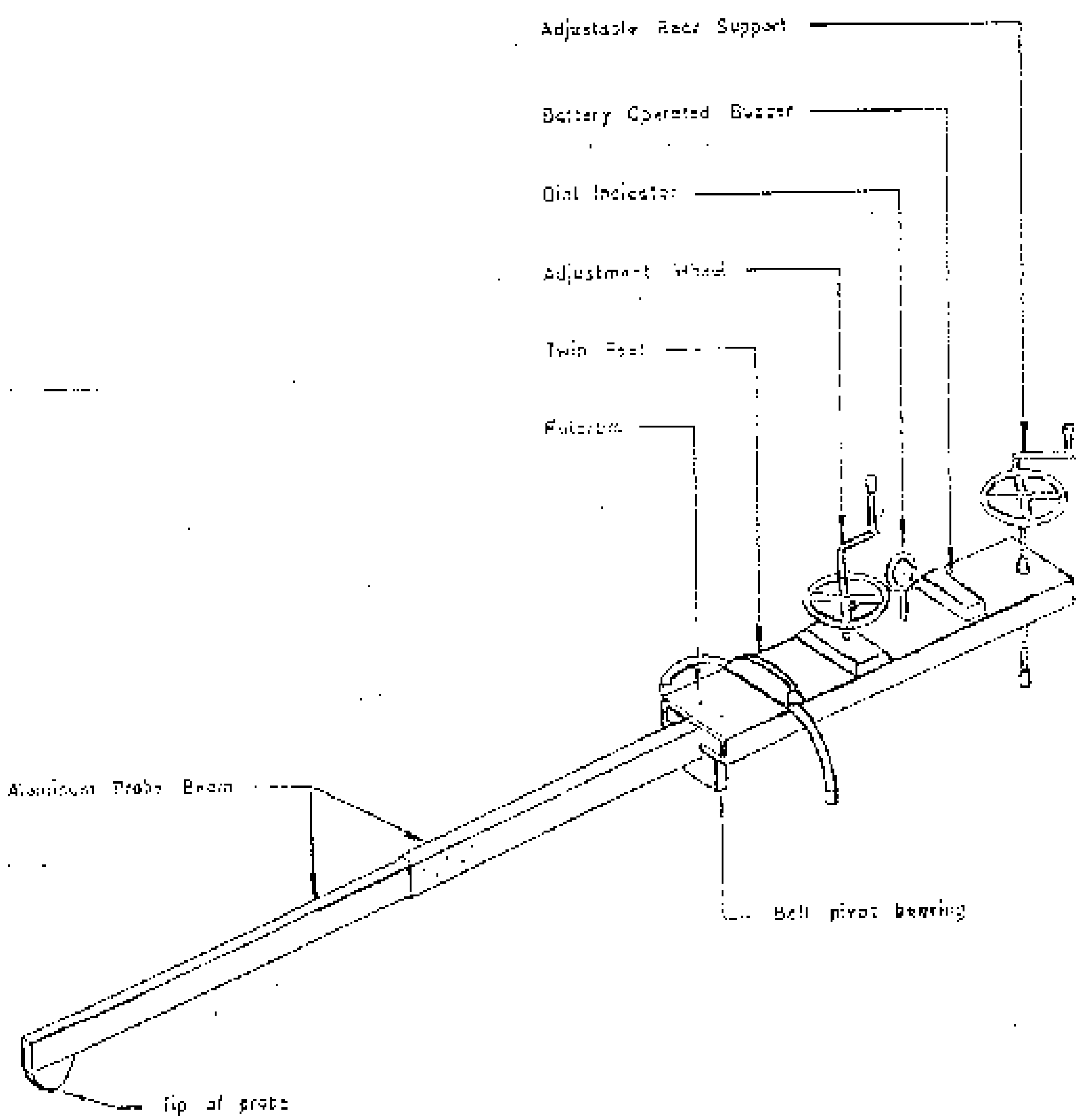


Fig. 3 Benkelman Beam