CONSTRUCTION AND QUALITY CONTROL OF FLEXIBLE AND RIGID PAVEMENTS

Use of Benkelman Beam and Light Weight Deflectometer for Structural Evaluation

National Rural Infrastructure Development Agency

Ministry of Rural Development

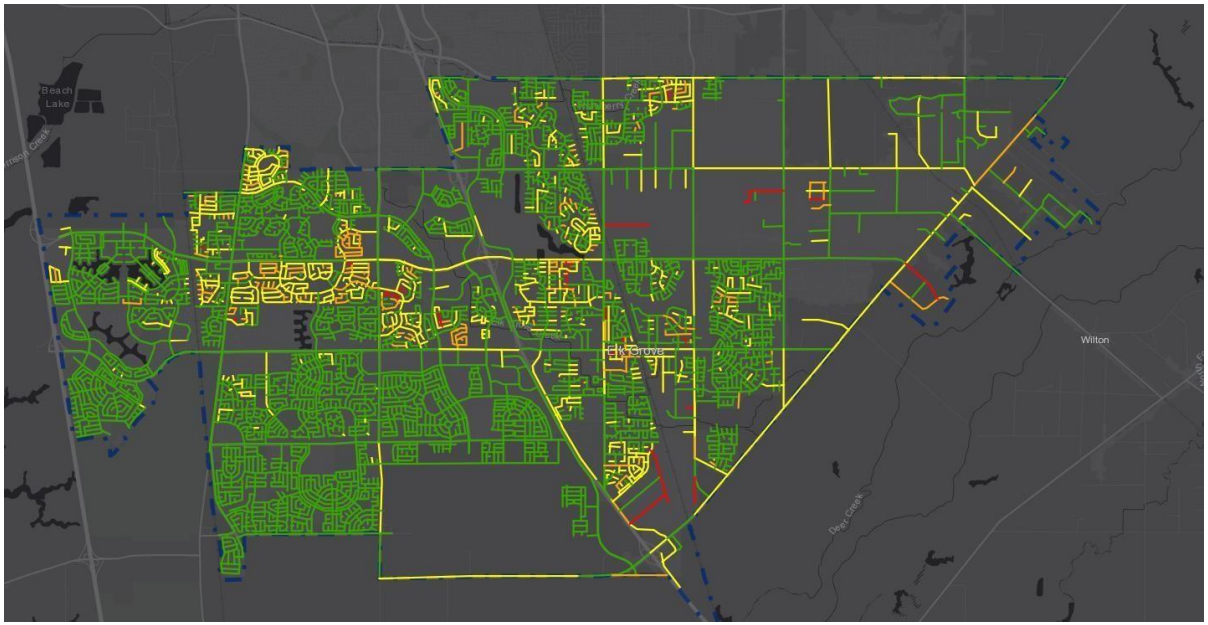
National Institute of Technology

Warangal, Hyderabad

Lecture-7

Use of Benkelman Beam and Light Weight Deflectometer for Structural Evaluation

At Network level PMS



At network level, we used a measure of riding comfort (roughness) to categorize the roads to 'Good', 'Fair' and 'Poor'

At Network level PMS

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S. No.	Type of Surface	Condition of Road Surface					
		Good		Fair		Poor	
		RI	IRI	RI	IRI	RI	IRI
1	Surface Dressing	<3000	<4.03	3000-3800	4.03-4.98	>3800	>4.98
2	Open Graded Premix Carpet	<2800	<3.79	2800-3500	3.79-4.62	>3500	>4.62
3	Mix Seal Surfacing	<2600	<3.55	2600-3200	3.55-4.27	>3200	>4.27
4	Semi Dense Bituminous Concrete	<2200	<3.05	2200-3000	3.05-4.03	>3000	>4.03
5	Bituminous Concrete	<2000	<2.81	2000-2600	2.81-3.55	>2600	>3.55
6	Cement Concrete	<2200	<3.05	2200-2600	3.05-3.55	>2600	>3.55

Maximum permissible roughness for MDR and ODR (IRC SP 16-2019)

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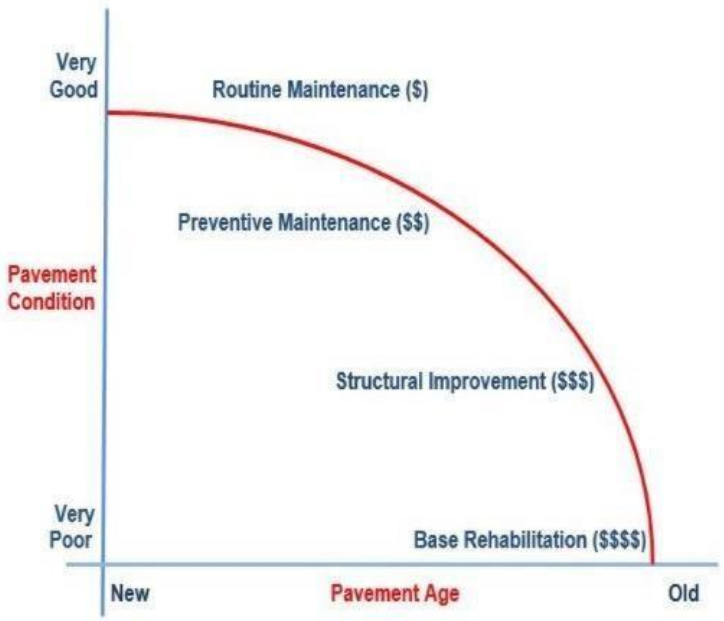
4	Semi Dense Bituminous Concrete	<2400	<3.30	2400-3000	3.30-4.03	>3000	>4.03
5	Cement Concrete	<2200	<3.05	2200-2600	3.05-3.55	>2600	>3.55

Maximum permissible roughness for village roads (IRC SP 16-2019)

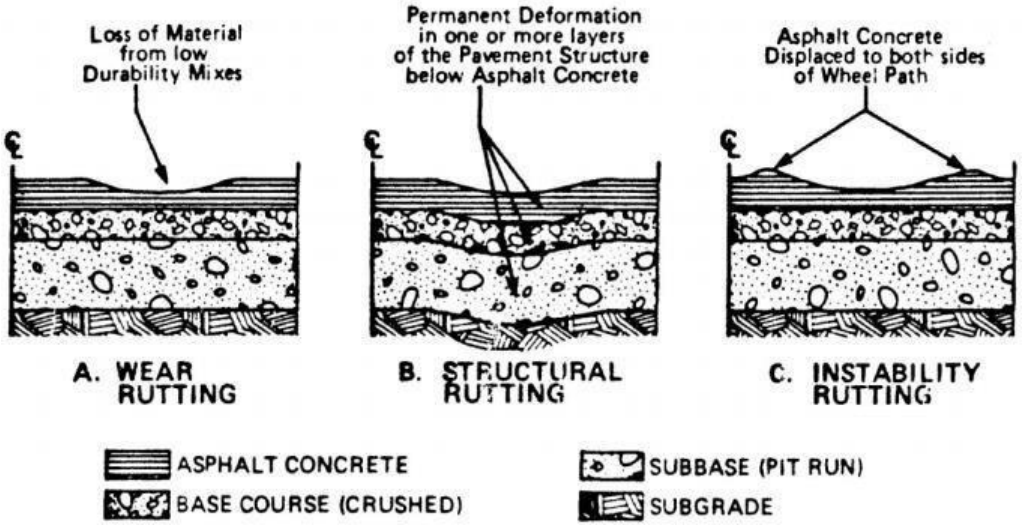


PCI Range	Pavement Condition	Recommended Action	Cost/square meter (Rs)
0 - 24	Very Poor	Complete reconstruction, full depth reclamation - correcting from base layer	4000
25 - 47	Poor	Structural improvement- milling of the distressed top 50-100 mm of asphalt layer, recycling, and laying of structural overlay	1500
48 - 67	Fair	Preventive maintenace - Sealing of cracks, patching, micro-surfacing, correcting the pavement in-order to reinstate the functional condition of pavement, minor rehabilitation overlay	600
68 - 87	Good	Routine maintenance - to prevent/reduce the dteterioration of the road due to ageing and traffic loading. Crack sealing, slurry seal, correcting drains, shoulder dressing	100
85 - 100	Very good	Do nothing - when the road is perfectly fine	0

For the road network, in-order to reinstate the overall health of the network to fair condition – we can work out the Budget that is required for a financial year

Against the budget we applied for the financial year, we would receive the allotted budget – However the budget allotted will be constrained !!!

Necessity of diagnosing the pavement distress - Treatment differs !!!!



Necessity of diagnosing the pavement distress - Treatment differs !!!!

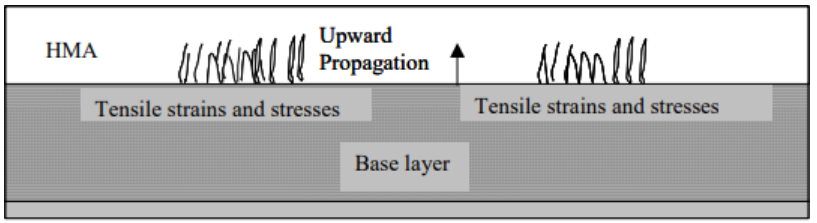


Figure 3.3.3. Bottom-up fatigue cracking.

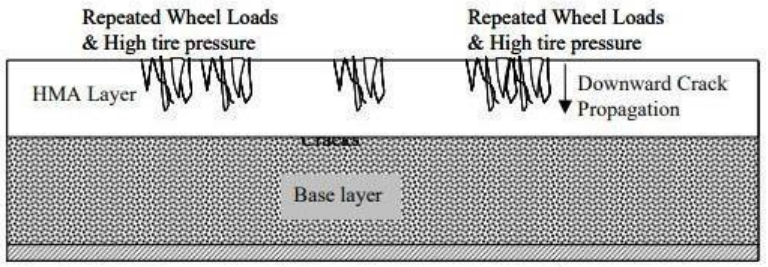
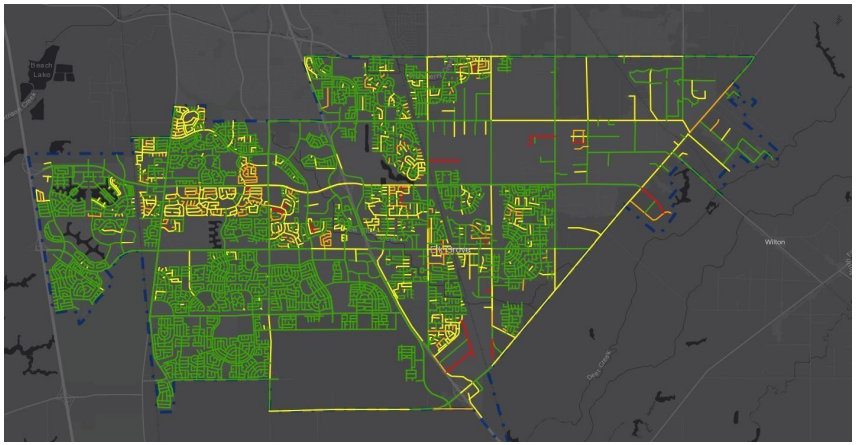
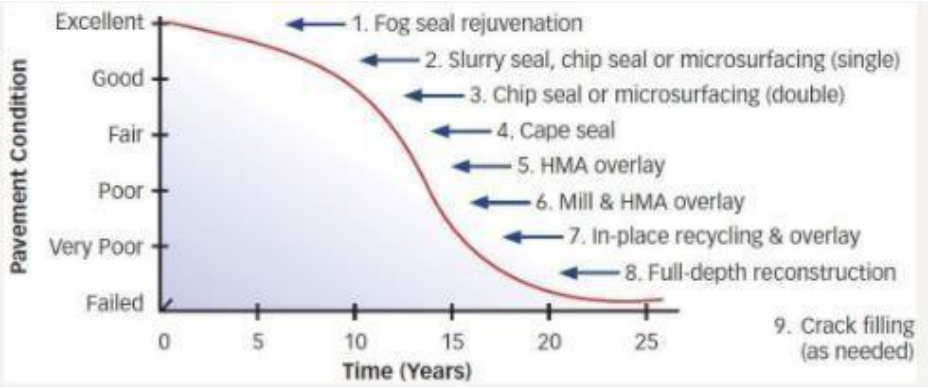


Figure 3.3.4. Top-down fatigue cracking.

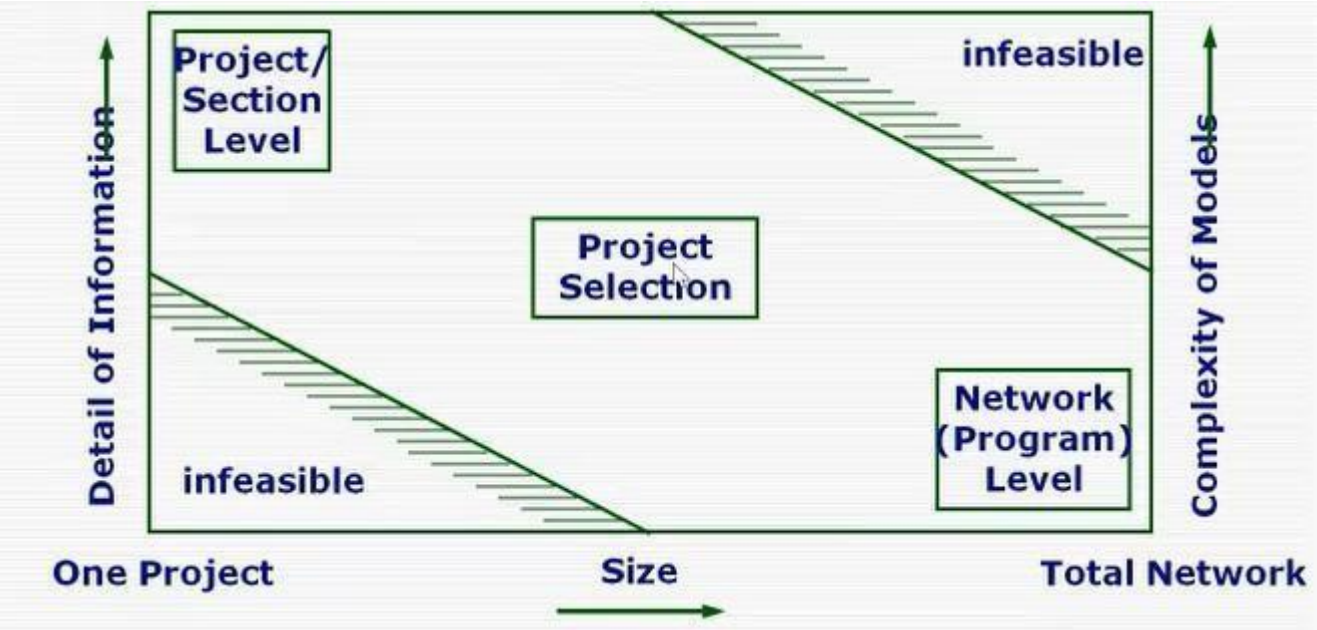
Necessity of diagnosing the pavement distress - Treatment differs !!!!





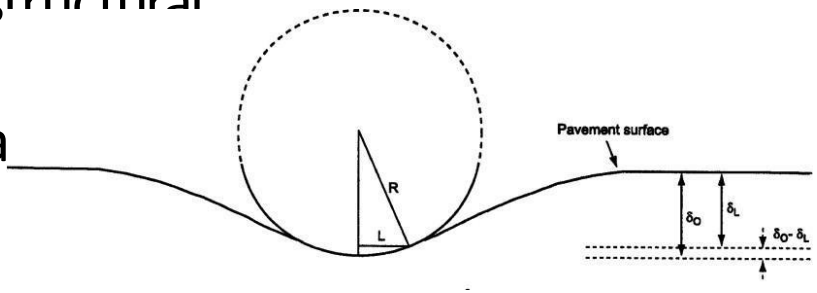
Within the budget allotted, it is necessary to identify which all roads are to be identified for the present year, identify the treatment, estimate the budget requirement at project level. At Project level, the kind of data what we require is different from the data what we require at network level

Information level required at Project level, Project selection level and at Network level



Project level Pavement Management System

- The PCI or PSI surveys will estimate the distress rating of roads in the total network.These are ratings given on distresses evaluated visibly
- To plan the type of rehabilitation/maintenance,it is required to revisit the pavements, assess the structural condition of the pavement
- The easiest structural response tha can be quantified is pavement deflection



Pavement response to load

Pavements, based on its composition, respond differently to different magnitude of loading. Based on structural strength, it can deflect more/less to the applied load

Pavement Deflection

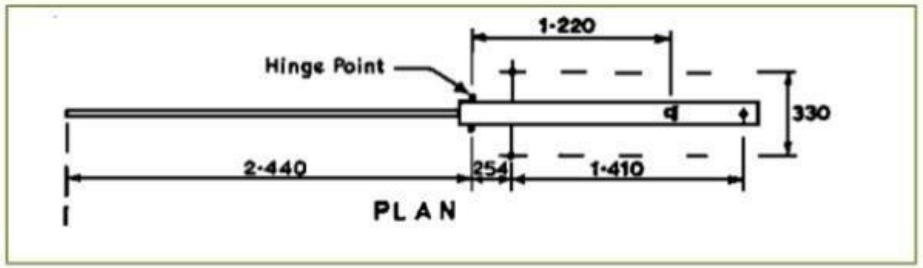
- Deflection of the pavement under a standard load can distinguish strong and weak pavements.Weaker pavements deflect more
- It is essential to determine the deflection of the pavement under the application of standard loading (80 kN axle)
- The standard load application is important as the pavement is designed for the standard axle load
- Deflection bowl – interpretations of the shape of the curve can also provide useful information about the pavement health

Instruments for measuring Pavement Deflection

- Benkleman beam deflectometer
- Light Weight deflectometer
- Falling weight deflectometers
- Rolling falling weight deflectometer

Benkelman beam deflectometer

- Consist of slender beam of length 3.66 m.
- Pivoted at 2.44 m from probe.
- distance from pivot to dial gauge 1.22 m.
- Distance from pivot to front leg 25 cm.
- Distance from pivot to rear leg 1.66 m.



Schematic diagram of BBD deflection technique

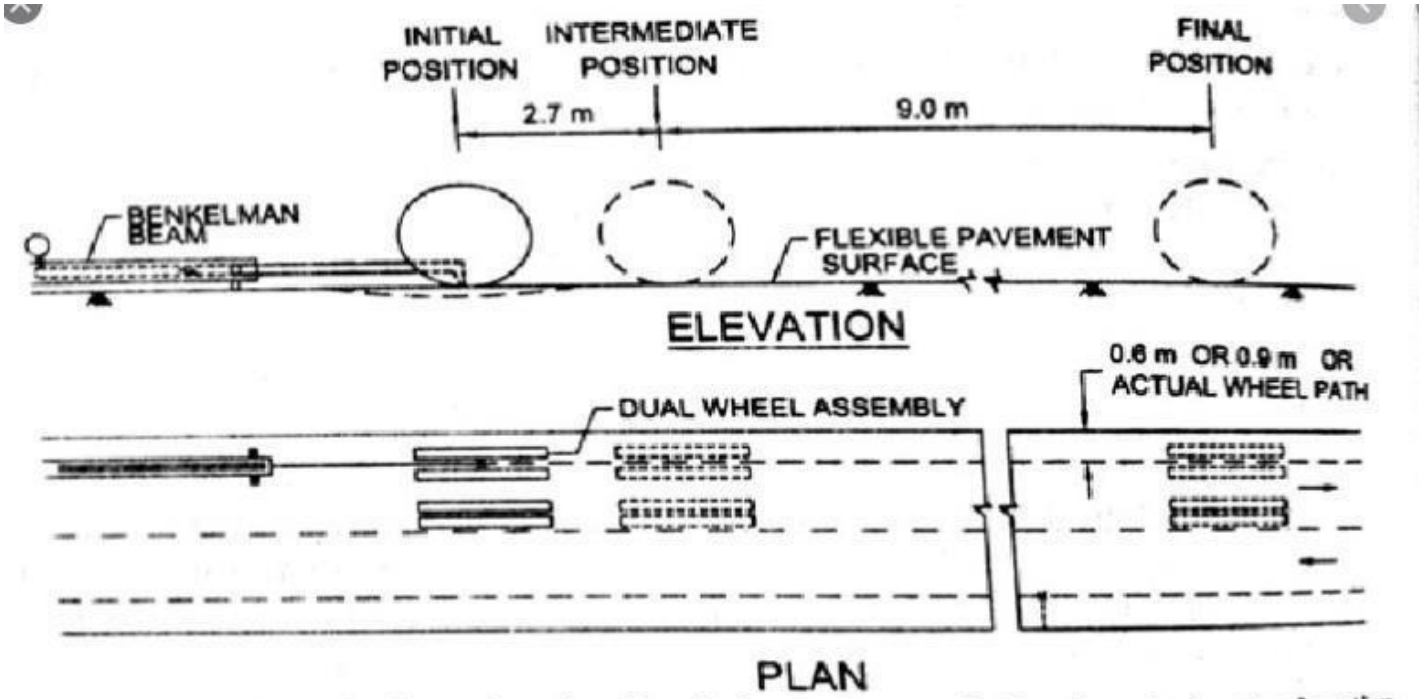


Fig. 10.12 Method of conducting Benkelman beam deflection study at a location

Determination of characteristic pavement deflection

- Pavement deflections measured using any instrument needs to be corrected for temperature and seasonal moisture variation
- The number of deflection measurements to be taken depends on the initial assessment of road based classification of pavement condition based on rut depth and cracked area
- Three readings
  - Initial deflection, intermediate and final deflection is noted
  - If the difference b/w intermediate and final reading is less than 0.025 mm
    Pavement deflection = 2 (difference b/w final and initial reading)
  - If the difference b/w intermediate and final reading is greater than 0.025 mm

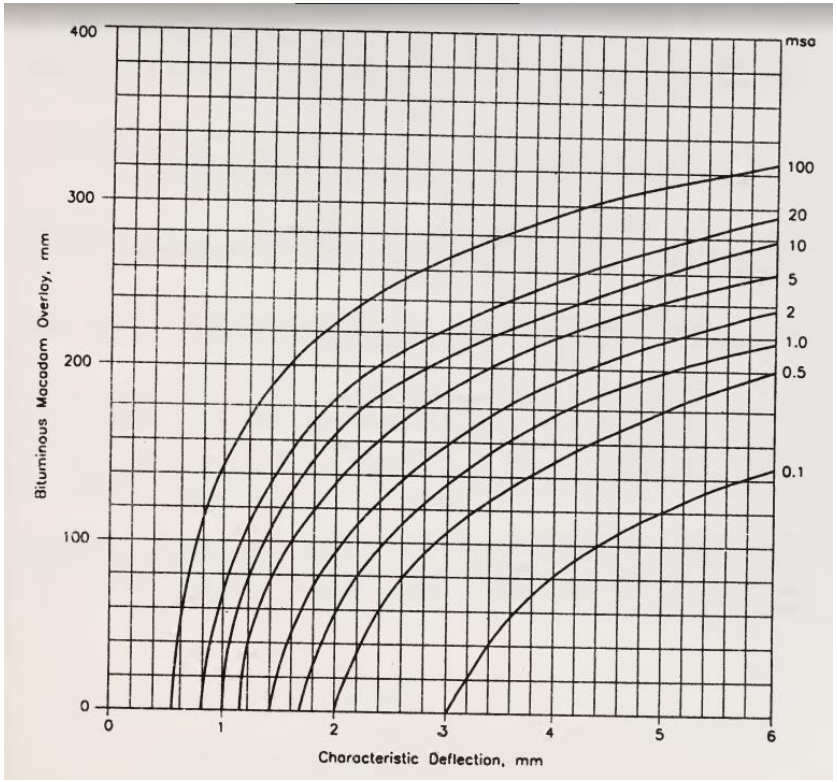
    Pavement deflection = 2(difference b/w final and initial reading)
    + 2.91 (diff b/w final and intermediate reading)
- Based on the characteristic deflection measured, overlay thickness can be estimated

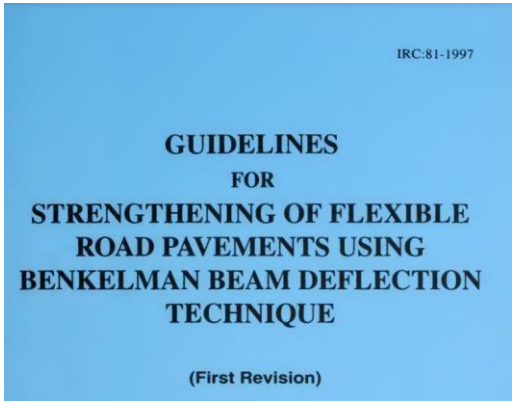
Threshold values of rebound deflection

Distress / Treatment	Roughness m/km	Rebound deflection mm	Rut Depth mm	Cracking %
Preventive Maintenance	3.00	-	10.00	10.00
Major Rehabilitation	4.50	1.00	15.00	15.00
Reconstruction	6.00	1.25	20.00	20.00

Reference: Chethana Ramachandran (2020)

Overlay design guidelines based on structural assessment - IRC 81-1997



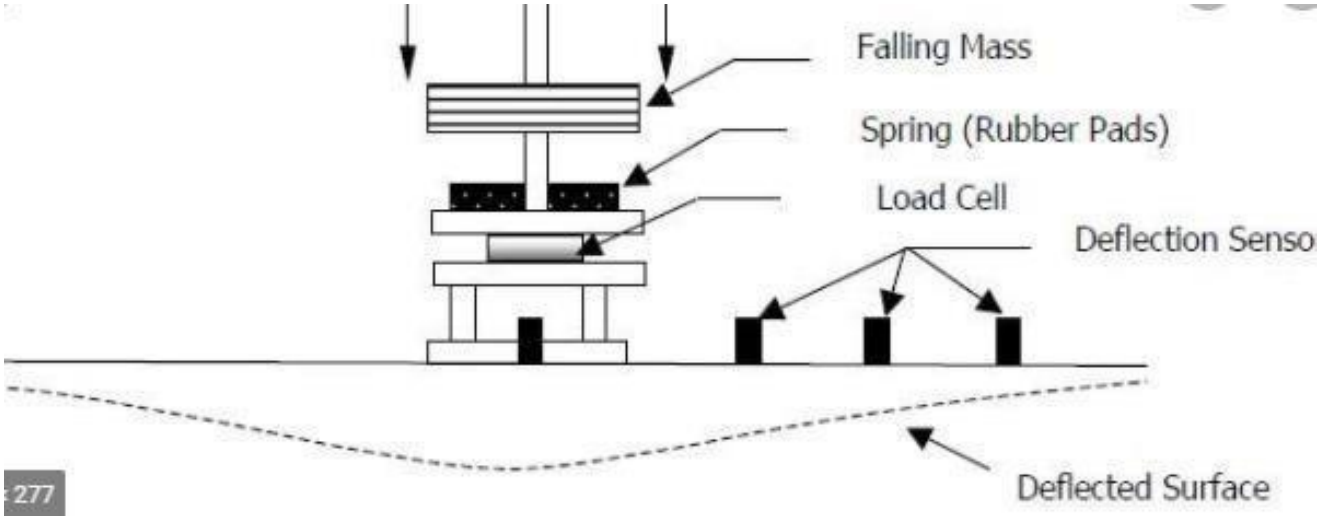


Drawback of BBD

- Pavement deflection is measured using a static wheel load
- Health of the pavement is assessed by means of one deflection (central deflection) alone
- Two pavements can have the same central deflection, but different structural behavior

Falling weight deflectometers

Principle of Falling weight deflectometer



Assessment of health condition of pavement layers from deflection bowl parameters

Figure 1.1 – Dynatest Model 8000 FWD.

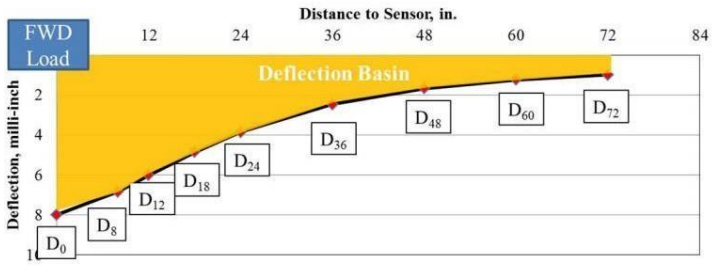


Figure 1.2 – FWD testing schematic.

Table 3. Benchmark values for deflection bowl parameters BLI, MLI, LLI, and RoC.[10]

Pavement Section	Structural Condition Rating	D_0 (μm)	*RoC* (μm)	*BLI* (μm)	*MLI* (μm)	*LLI* (μm)
Granular base	Sound	< 500	> 100	< 200	< 100	< 50
	Warning	500-750	50-100	200-400	100-200	50-100
	Severe	> 750	< 50	> 400	> 200	> 100
Cementitious base	Sound	< 200	> 150	< 100	< 50	< 40
	Warning	200-400	80-150	100-300	50-100	40-80
	Severe	> 400	< 80	> 300	> 100	> 80
Bituminous base	Sound	< 400	> 250	< 200	< 100	< 50
	Severe	400-600	100-250	200-400	100-150	50-80
	Warning	> 600	< 100	> 400	> 150	> 80

1 inch = 25.4 mm.

Source: Chapter 2. Deflection Testing Guidelines - Using Falling Weight Deflectometer Data With Mechanistic-Empirical Design and Analysis, Volume III: Guidelines for Deflection Testing, Analysis, and Interpretation , December 2017 - FHWA-HRT-16-011 (dot.gov)

Overlay design guidelines based on structural assessment - IRC 115-2014 & IRC 117 - 2014

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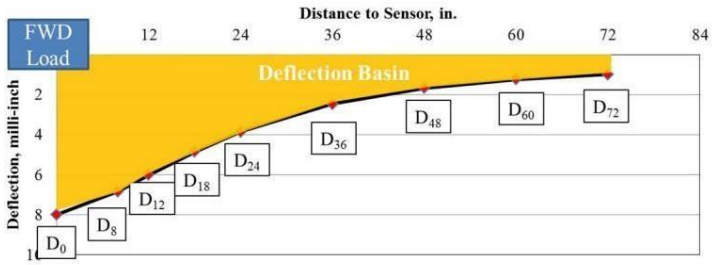


Figure 1.2 – FWD testing schematic.

IRC:115-2014

GUIDELINES
FOR
STRUCTURAL EVALUATION
AND
STRENGTHENING OF FLEXIBLE
ROAD PAVEMENTS USING
FALLING WEIGHT DEFLECTOMETER (FWD)
TECHNIQUE

IRC:117-2014

GUIDELINES
FOR
THE STRUCTURAL
EVALUATION OF RIGID PAVEMENT
BY
FALLING WEIGHT DEFLECTOMETER

Dynamic cone Penetrometer (DCP)

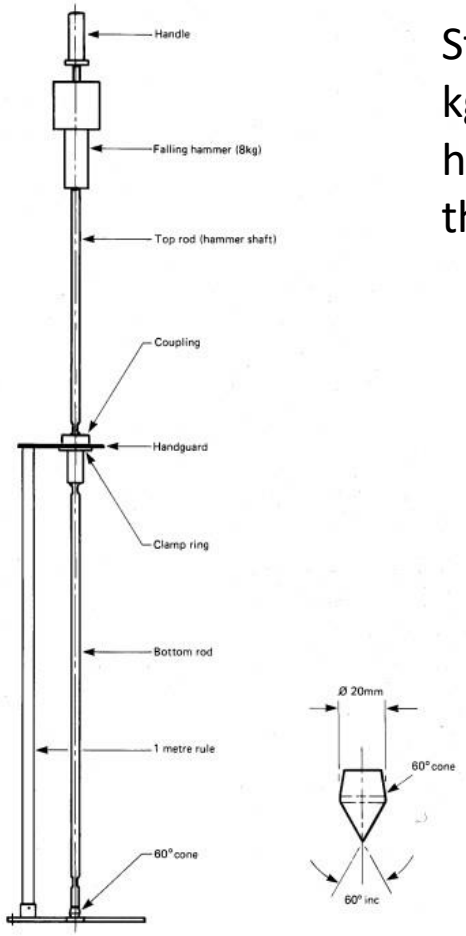
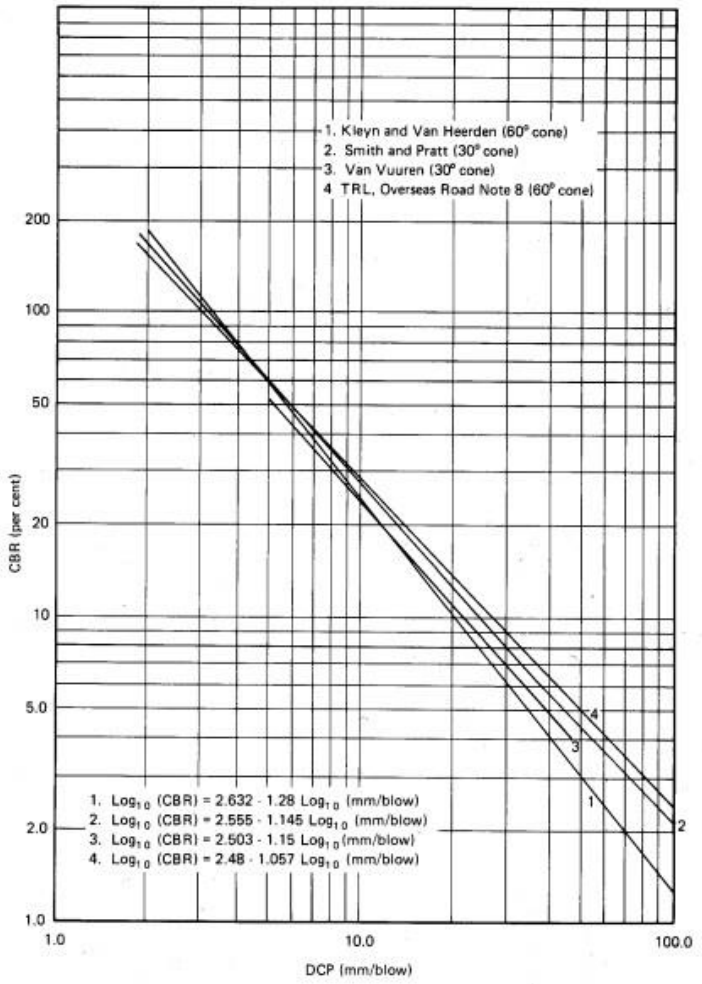
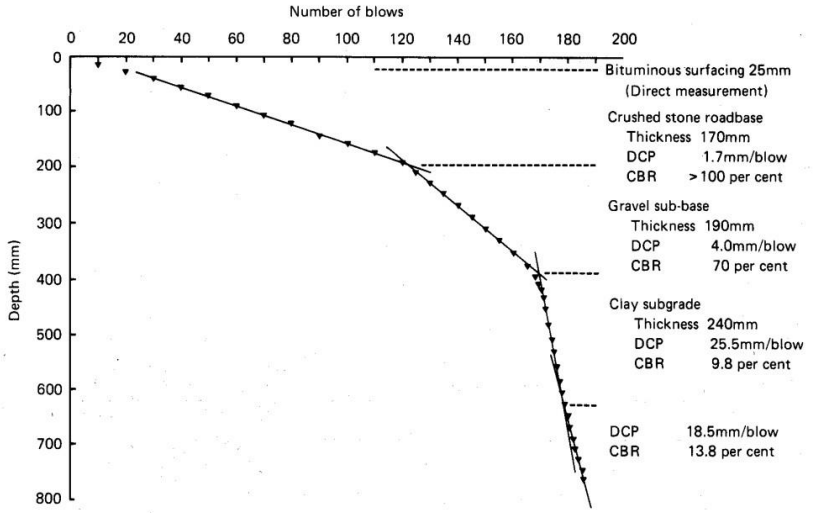


Fig.C1 TRL Dynamic cone penetrometer

Standard weight of 8 kg, falling from a height of 575 mm, through a guide rod

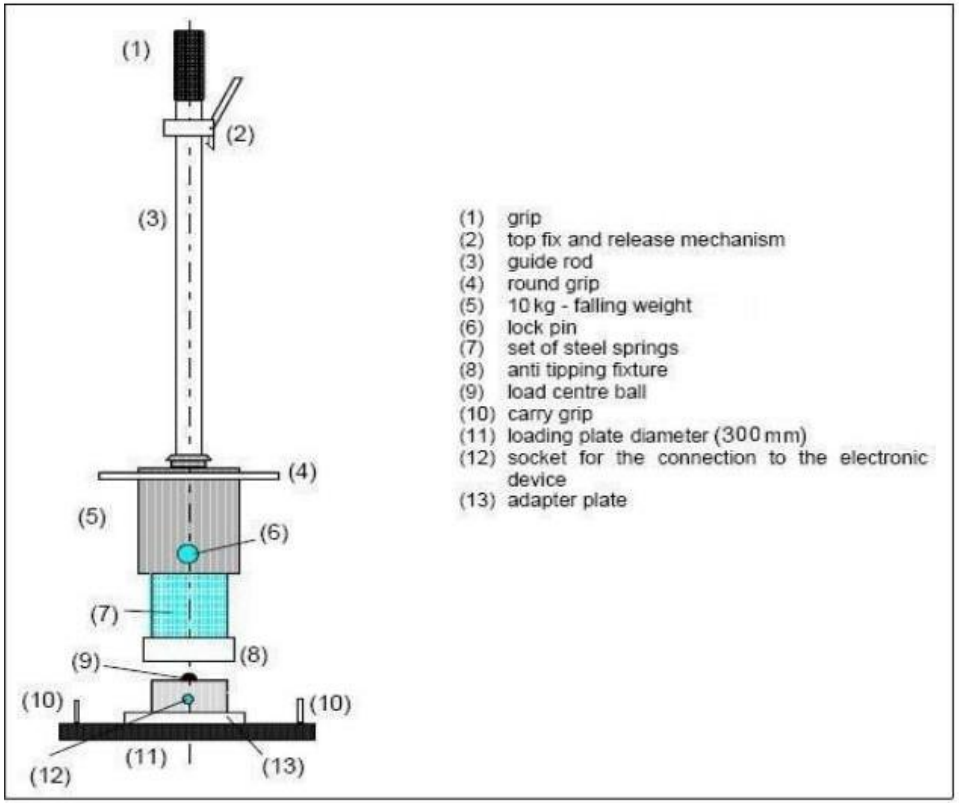
Dynamic Cone Penetrometer (DCP)



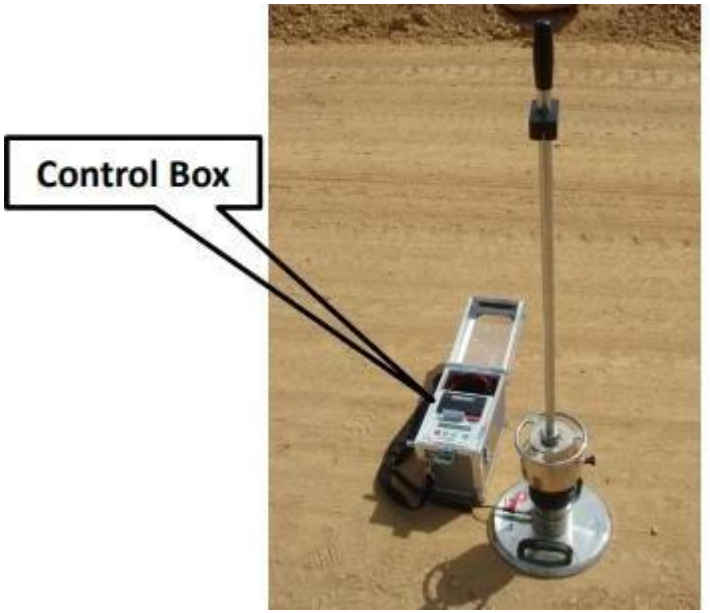


Source: TRL Overseas Road Note 31

Light weight deflectometers



(1) grip
(2) top fix and release mechanism
(3) guide rod
(4) round grip
(5) 10 kg - falling weight
(6) lock pin
(7) set of steel springs
(8) anti tipping fixture
(9) load centre ball
(10) carry grip
(11) loading plate diameter (300 mm)
(12) socket for the connection to the electronic device
(13) adapter plate



Light weight deflectometers - Ideal for evaluating subgrade construction quality

(a) Putting the load plate on level surface

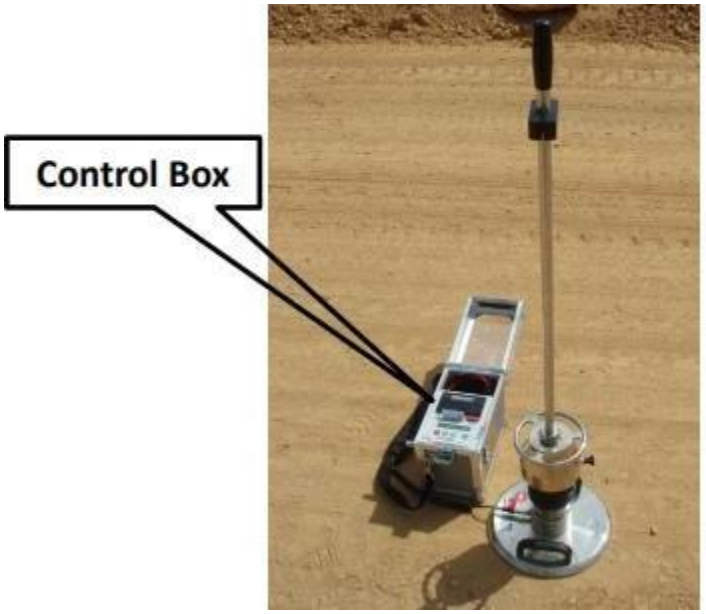
(b) Connecting the mechanical part and electronic unit with a cable

(c) Preparing the device for testing

(d) Results Printouts

LWD Test procedure

- Select location and setup LWD connection to its computational unit
- The surface shall be levelled
- Set the plate on a prepared subgrade and seat it by turning left and right 45 degrees. Do not drop the plate on the prepared surface
- LWD plate shall not move laterally
- Perform 3 seating drops before collecting the data
- Of noticing excessive deflection, material needs additional compaction
- Following seating drops, perform 3 drops from a fixed height. Record the average of 4^{th}, 5^{th}, and 6^{th} drops



LWD specifications (Indiana DOT specifications)

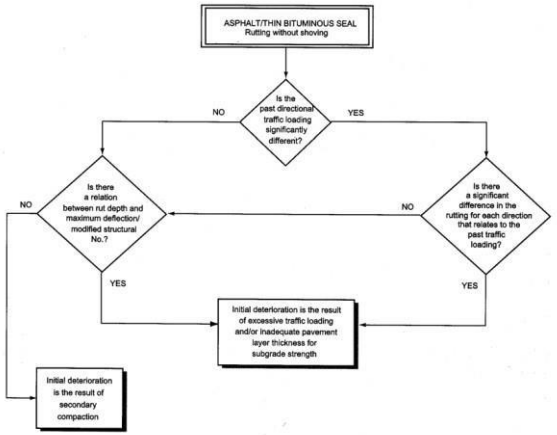
Material Type	Allowable Average Deflection (mm)	Maximum Deflection at a Single Test Location (mm)
Lime Modified Soil	≤ 0.30	0.35
Cement Modified	≤ 0.27	0.31
Aggregate over Lime Modified Soil	≤ 0.30	0.35
Aggregate over Cement Modified Soil	≤ 0.27	0.31

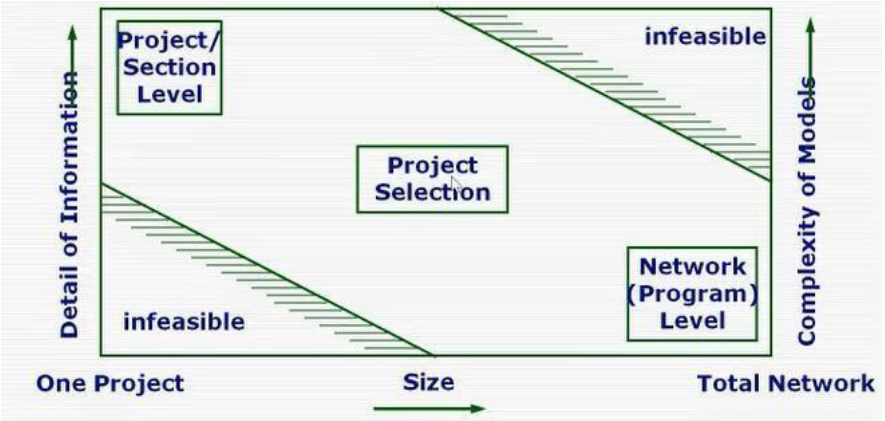
Material Thickness	Allowable Average Deflection (mm)	Maximum Deflection at a Single Test Location (mm)
6 in. Thick Coarse Aggregate No.53	≤ 0.60	0.65
12 in. Thick Coarse Aggregate No.53	≤ 0.47	0.52**
18 in. Thick Coarse Aggregate No.53	≤ 0.44	0.49**

* *When deflection exceed this value, the area shall be recompacted or undercut as directed. The failed area shall be delineated prior to excavation. Deflection will be measured based on the top 6 in. thick coarse aggregate No. 53 layer material placed for undercut.*

** *The Contractor shall recompact the coarse aggregate No.53 in accordance with 301.06 .*

Project level data collection





Exact identification of pavement distress, its causes is essential for deciding the treatment that is applied.Structural evaluation of pavements