

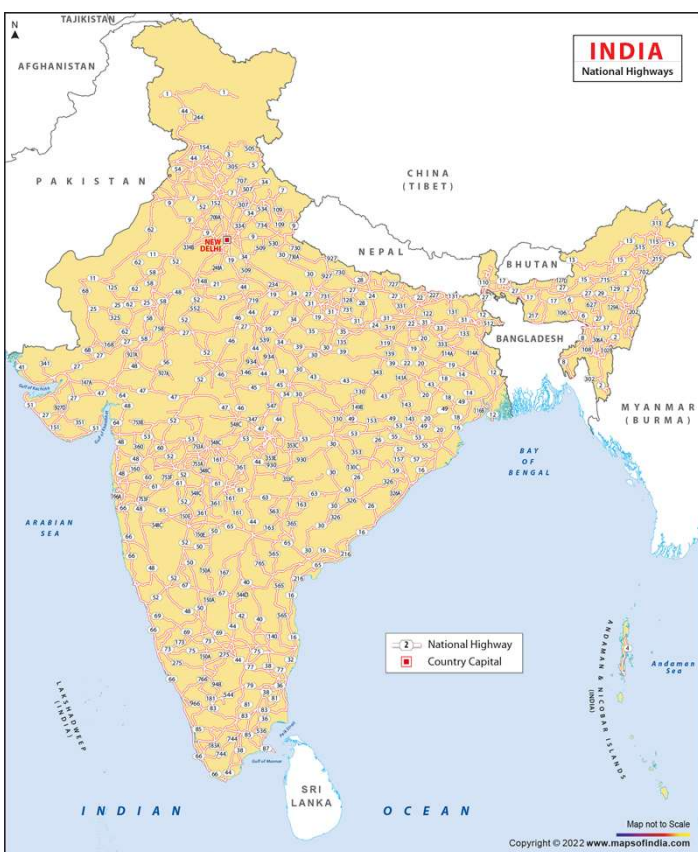
## HOAI Webinar Series 2025



## Highway Health Check: Mastering Pavement Distress & NSV - 6<sup>th</sup> May 2025

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**INTERISE**

## Highway Network



- India has a total road network of approximately 6.7 million kilometers (kms), making it the second-largest road network in the world.

### Road Network Statistics

Category	Length (km)	Length (%)
National Highway (MORTH)	151,000	2.19
State Highway (PWD)	186,528	3.00
District Road (PWD)	632,154	10.17
Rural Road (PMGSY)	4,535,511	72.97
Urban Road (Municipal Corporation)	544,683	8.76
Project Road (SAIL/ NMDC/ BRO etc.)	354,921	5.7
Total	6,404,797	100

- Road network of India carries 60-71% of freight and 87-95% of passenger traffic. India's freight transport market is huge and growing, valued at 157.45 billion USD in 2024 and projected to 222.14 billion USD by 2034
- National Highways which are mere 2% of the total road network carries almost 40 to 50% of the total freight
- Majority of the National highways in India are flexible (bituminous) pavement.

## Road Quality Index

- Majorly two factors are determined to evaluate the quality of road infrastructure in the world.
- **Mean Speed Score** : International Monetary Fund (IMF)
  - MS score is a measure of cross-country road quality based on the travel time between large cities according to Google Maps.
  - **“India has mean speed score of 58 compared to around 100 scored by the chart leaders”.**
- **Road Quality Indicator** : World Economic Forum (WEF)
  - It is one of the components of the Global Competitiveness Index published annually. This score is given based on a long-running and extensive survey, tapping the opinions of over 14,000 business leaders in 144 countries.
  - The WEF Road quality indicator ranges in a scale of **1(low) - 7(high)**. The world average is **4.07 points** and India’s average updated on 2019 is **3.7 points**.

**Based on the 2024 statistics of IMF, Singapore is ranked as no 1 and India at 51st place in Road Quality Index.**

Can we be the no 1.... If Yes, then How?

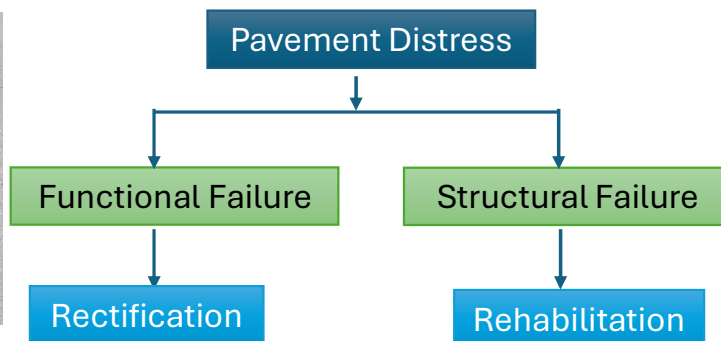


## Types of Pavement Distress – Bituminous Pavement

- More than 90 % of pavement in India are Flexible in Nature.
- If effective pavement maintenance management system been implemented, India can improve its ranking and road quality index.
- Flexible pavements shall have pavement distresses broadly categorized in to Structural and Functional failure



Typical Functional Failures



Typical Structural Failures



## Causes and Impact of Pavement Distress

### Causes

Traffic Loading



Poor Construction Practices



Poor Quality Soil for Subgrade



Improper Drainage



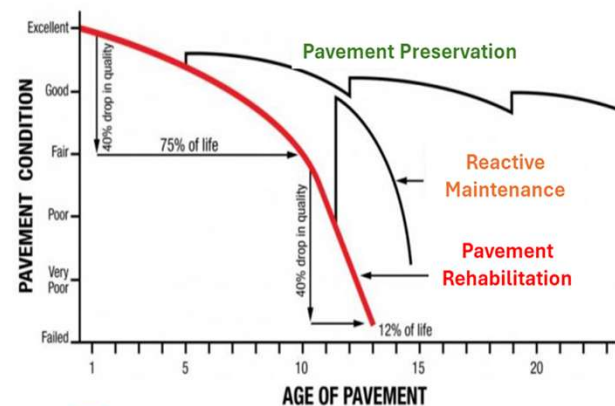
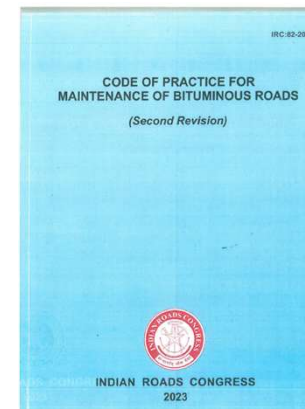
### Impact

- Safety
- Riding Quality and Comfort of road users
- Vehicle operation cost
- Integrity of Pavement Structural Health and Life cycle cost
- Overall Economic Growth of the Country

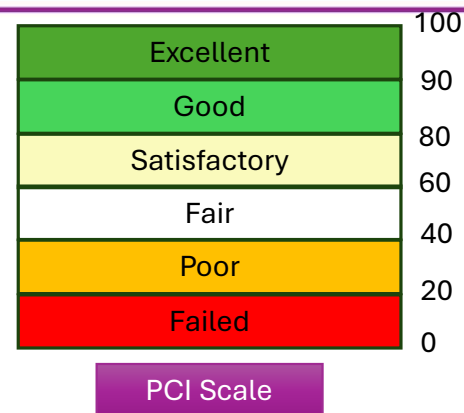
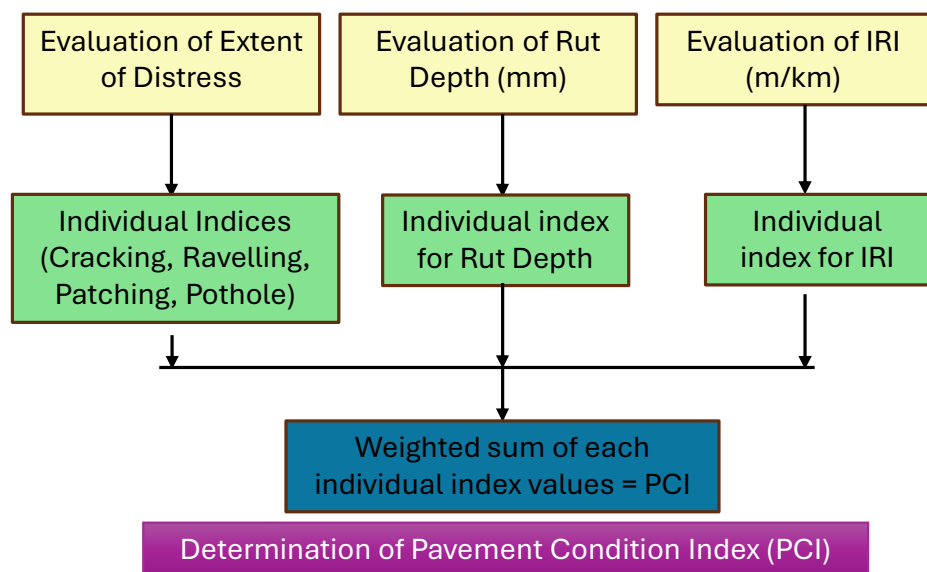
Thus, Identifying, Understanding, and Measuring Pavement Distresses Accurately and its timely Rectification Becomes Necessary.....

## Distress Maintenance of Flexible Pavements

- Flexible pavements shall be maintained as per IRC: 82.
- And the Flexible pavement maintenance are broadly classified in to three categories.
- Routine Maintenance** - It is conducted throughout the year to maintain basic functionality of the pavement, like pothole filling, repair of cracks, patch work etc.
- Preventive Maintenance** – It is performed to improve or extend the functional life of pavement surface while in good structural condition.
- Periodic Maintenance** – This includes regular maintenance operations compared to preventive maintenance to be carried out at specified frequency based upon condition or performance of the road surface.
- IRC 82 evaluates a pavement based on Pavement Condition Index (PCI).



## Distress Measurement and Maintenance as per IRC 82: 2023

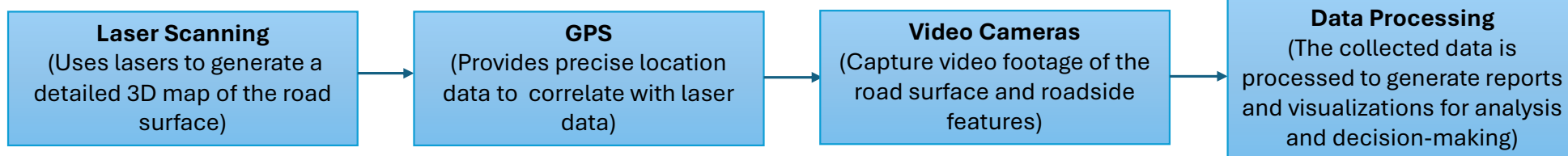


Condition	Excellent to Good		Satisfactory to Fair		Poor to Fail	
	Excellent	Good	Satisfactory	Fair	Poor	Fail
PCI	> 90 to 100	> 80 to 90	> 60 to 80	> 40 to 60	> 20 to 40	0 to 20
Recommendations	Routine	Preventive	Renewal	Minor Rehabilitation	Major Rehabilitation	Re –Construction

Extent of pavement distresses can be measured based on visual pavement condition survey and NSV (Network Survey Vehicle)

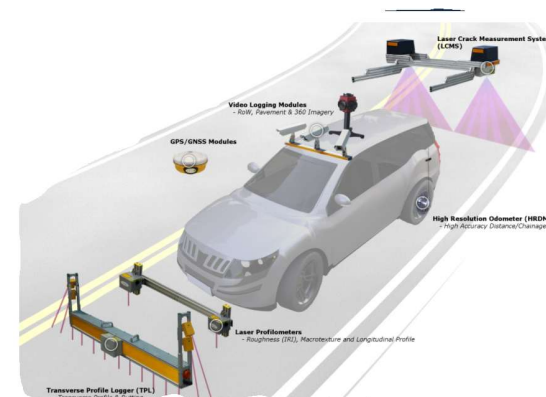
## Network Survey Vehicle (NSV)

- **A Network Survey Vehicle (NSV)** is a specialized vehicle equipped with technologies like lasers, GPS, and video imaging to collect road condition and inventory data.
- **How it works:**



- **Road Data Collection**

- **Longitudinal and Transverse Profiling:** Measures the surface profile of the road to assess roughness and rut depth.
- **Pavement Texture:** Evaluates the texture of the road surface.
- **Road Geometry:** Captures data on road alignment, cross-slopes, and curves.
- **GPS Coordinates:** Provides accurate location data for each section of the road.
- **Video Imaging:** Captures video footage of the road surface and roadside features for visual documentation and analysis.





## Measurement of Pavement Condition Index as per IRC 82: 2023

### Distress Extent

$$PCI_{CRACKING} = \frac{7231}{CE^2 - 0.737 \times CE + 73.09}$$

Where CE=Crack Extent

$$PCI_{POTHOLE} = \frac{-80.32 \times PN^3 + 1129 \times PN^2 - 3524 \times PN + 3566}{PN^3 + 5.791 \times PN^2 - 28.67 \times PN + 35.72}$$

Where PN = Pothole number

$$PCI_{RAVEL} = 52.92 * e^{-0.02525 * RE} + 44.1 * e^{-0.2899 * RE}$$

Where RE=Ravelling Extent

$$PCI_{PATCH} = 52.92 * e^{-0.02525 * PE} + 44.1 * e^{-0.2899 * PE}$$

Where PE = Patch Extent

$$\text{Extent} = \frac{\text{Surface Area of Pavement Section affected by a distress}}{\text{Total Surface area of Pavement Section}} \times 100$$

### RUT Depth Index

$$PCI_{RUT} = \frac{7231}{RD^2 - 0.737 \times RD + 73.09}$$

Where RD = Rut Depth (mm)

### Roughness PCI

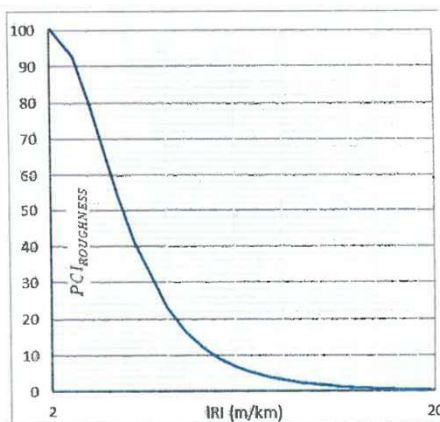
$$PCI_{ROUGHNESS} = \frac{100}{IRI^{1.91} - 3.542 \times IRI + 4.315}$$

## Distress Measurement Criteria

### Pavement Condition Index

Area of Crack	Cracks Extent %	Crack PCI	Pothole Area (m2)	Pothole Number	Pothole PCI	Ravelling Area	Ravelling Extent %	Ravelling PCI	Patching Area	Patching Extent %	Patching PCI	IRI in m/Km	IRI PCI	Rut Depth in mm	Rut Depth PCI	TOTAL PCI	Rating
0.0038	0.004	98.94	0.00	0	99.83	0.34	0.32	92.64	0.00	0.00	97.02	0.20	27.38	3.20	89.30	68.32	Satisfactory
1.8657	0.533	99.08	0.10	1	78.80	3.63	1.04	84.21	4.52	1.29	81.56	1.67	94.08	2.80	91.69	89.91	Excellent
0.0692	0.020	98.95	0.18	2	41.01	2.55	0.73	87.65	15.88	4.54	59.03	1.00	56.40	2.80	91.69	67.32	Satisfactory
0.0738	0.021	98.95	0.25	3	34.21	4.70	1.34	81.02	7.49	2.14	73.85	2.55	79.36	1.90	96.03	76.55	Satisfactory
0.9440	0.270	99.10	0.38	4	30.81	6.26	1.79	76.84	9.63	2.75	69.22	2.00	101.10	2.50	93.31	83.55	Good
12.3900	3.540	87.11	0.44	5	25.48	3.81	1.09	83.67	3.75	1.07	83.85	1.88	100.48	3.30	88.67	82.21	Good

- PCI decreases with increase in Extent of Distress.
- IRI and Pothole has maximum impact on PCI.
- For IRI 2 m/km PCI is 100, however with decrease in IRI less than 2, PCI further decreases.
- For IRI less than 2 m/km, PCI should be considered as 100? Guidelines are not clear.



Distress Parameter	PCI Weight
IRI	0.40
Pothole	0.16
Rut Depth	0.14
Cracking	0.12
Ravelling	0.10
patch Work	0.08

### Pavement Distress and Roughness Index Based Rating for Highways (IRC : 82-2023)

Defect Type	Range of Distress		
	Excellent to Good	Satisfactory to Fair	Poor to Fail
Cracking (%)	< 5	5 to 10	> 10
Ravelling (%)	< 1	1 to 10	> 10
Potholes (No)	Nil	1 to 2	> 2
Patching (%)	< 1	1 to 10	> 10
Rut Depth (mm)	< 5	5 to 10	> 10

## Distress Measurement Criteria

### Roughness

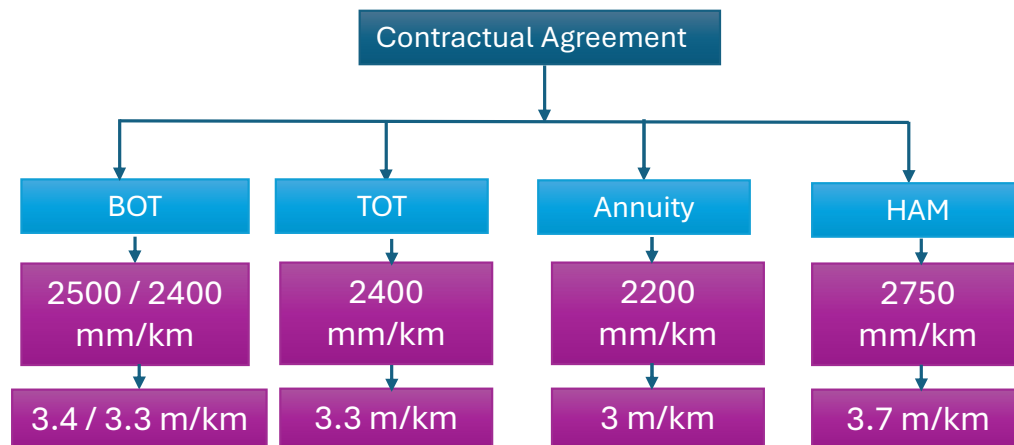
- Majority of Concession Agreements have minimum roughness value as maintenance criteria

Pavement Condition	Roughness Index (mm/km)
Excellent to Good	< 1800
Satisfactory to Poor	1800 to 2400
Poor to Fail	> 2400

Roughness Criteria as per IRC : 82 - 2023

- Example calculation for RI 1 m/km.

IRI discrepancy in calculation as per IRC 82							
As per Present IRC 82 Calculations				Recommended			
Original				Proposed			
Cracking	98.95	0.12	11.874	Cracking	98.95	0.12	11.87
Pothole	41.01	0.16	6.5616	Pothole	41.01	0.16	6.56
Ravelling	87.65	0.1	8.765	Ravelling	87.65	0.1	8.77
Patching	59.03	0.08	4.7224	Patching	59.03	0.08	4.72
IRI	56.4	0.4	22.56	IRI	100	0.4	40.00
Rut Depth	91.69	0.14	12.8366	Rut Depth	91.69	0.14	12.84
			67.3196				84.76
Satisfactory				Good			



$$RI = 630 (IRI)^{1.12} \quad (2.1)$$

Where, RI = Roughness Index in mm/km and IRI = International Roughness Index in m/km

## Drawbacks of NSV

### Potholes

- Clause 7.5.3.4 of IRC 82:2015 describes the severity of a pothole

#### 7.5.3.4 Severity

Potholes may be classified as small, medium and large (Photos 7.5.3 : a, b and c). A small pothole is defined as 25 mm deep and 200 mm wide. The medium pothole is defined as 25 to 50 mm deep and 500 mm wide. The large potholes are those greater than 50 mm deep and 500 mm width.

- No such definition is given in the revised code, IRC 82:2023. It defines one pothole unit as 300 mm dia circle
- An object like paper, polyethene bag, mud pump etc. are detected as potholes, thus the pothole number increases.
- Pothole PCI ~ No of potholes
- In one of the projects authority issued a letter for rectification of 2193 potholes, however, using the criteria of IRC 82: 2015 pothole numbers reduced to 115, and on ground actual

$$\text{No of Potholes} = \frac{\text{Surface Area of Pavement Section affected by potholes (m}^2\text{)}}{\text{Area of Pothole unit (i.e. 0.1 m}^2\text{)}} \times 100$$

Example: If the total area of potholing in the selected road length is 0.5 m<sup>2</sup>, then equivalent number of potholes shall be = 0.5/ 0.1, i.e. 5 potholes for PCI calculations.

Area (in Sq m)	No of Potholes (IRC 82: 2023)	Max Depth (in mm)	Average Depth (in mm)	Severity
0.009	9	10.800	6.700	Low
0.017	17	10.900	6.800	Low
0.018	18	10.500	7.800	Low
0.009	9	10.500	6.400	Low
0.011	11	10.100	6.700	Low
0.008	8	10.200	5.400	Low
0.010	10	10.800	6.800	Low
0.008	8	10.400	6.000	Low
0.005	5	10.500	6.600	Low
0.010	10	10.800	6.000	Low

Pothole data recorded in NSV



## Drawbacks of NSV

- **Accuracy of laser sensors gets compromised in following situations**
  - Wet Condition of Pavement
  - Pavement with High IRI – Sensors may get damaged and may need frequent calibration
- **Speed of NSV**
  - Data accuracy is compromised if speed is less than 20 kmph. On a busy road if overtaking is not possible, driving with designated speed becomes difficult and improper data gets collected
- **Skilled Operator/ Driver**
  - Accuracy and correctness of data greatly depends on the skill of the driver driving the vehicle and operator processing the data
- **Measurement of Roughness**
  - NSV roughness data includes measurement on speed breakers, WIM, road furniture, road marking etc. These areas should be excluded by visual inspection.



# *Thank You*

*For Your Attention*