



### SPTC Webinar Series

## Development of Marshall-RT Test for Evaluating Rutting Resistance of Plant-Produced Asphalt Mixes



### Presenter

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1

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2

2

## Presented Work and Contribution

Taylor & Francis Online

International Journal of Pavement Engineering >  
Volume 24, 2023 - Issue 1

Home > All Journals > International Journal of Pavement Engineering > List of Issues > Volume 24, Issue 1 > Exploring potential of Marshall-RT as simple performance test to evaluate rutting resistance of asphalt mixtures

362 Views

0 CrossRef citations to date

0 Altmetric

Research Article

### Exploring potential of Marshall-RT as simple performance test to evaluate rutting resistance of asphalt mixtures

Gavadakatla Vamsikrishna & Dharamveer Singh

Article: 2265030 | Received 20 Jul 2023, Accepted 25 Sep 2023, Published online: 06 Oct 2023

“ Cite this article https://doi.org/10.1080/10298436.2023.2265030 Check for updates



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Link: <https://www.tandfonline.com/doi/full/10.1080/10298436.2023.2265030>

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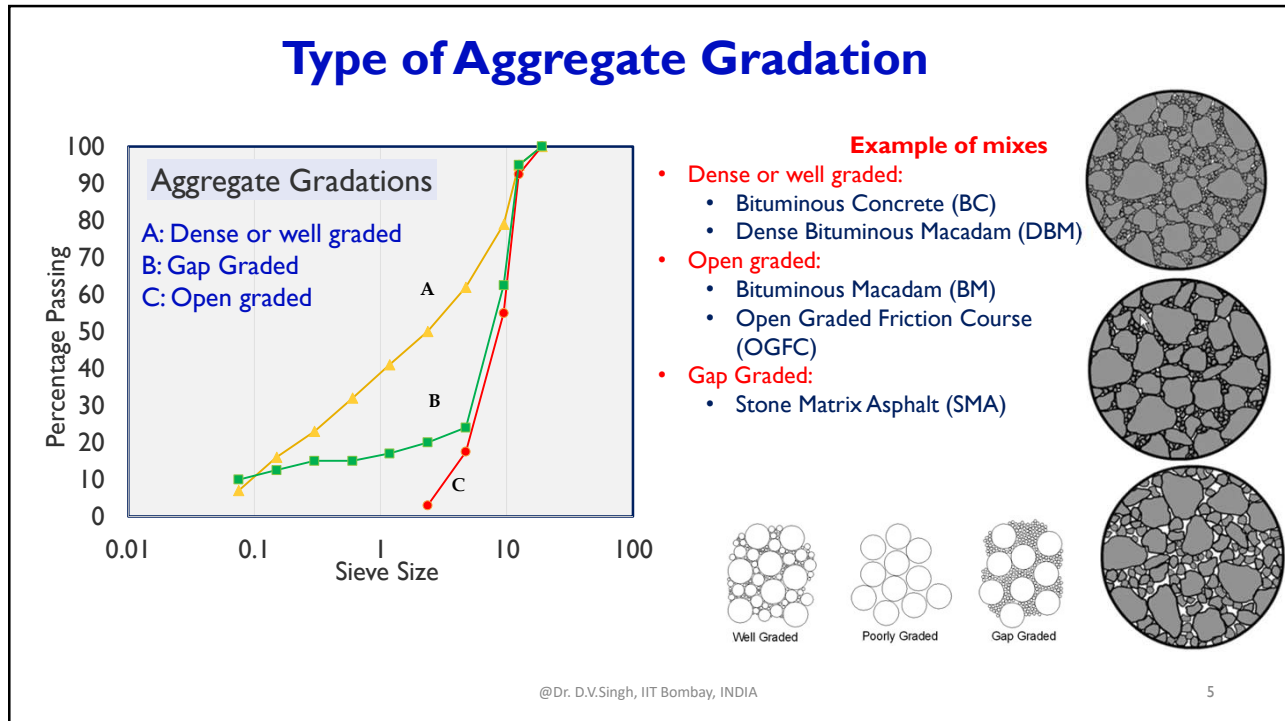
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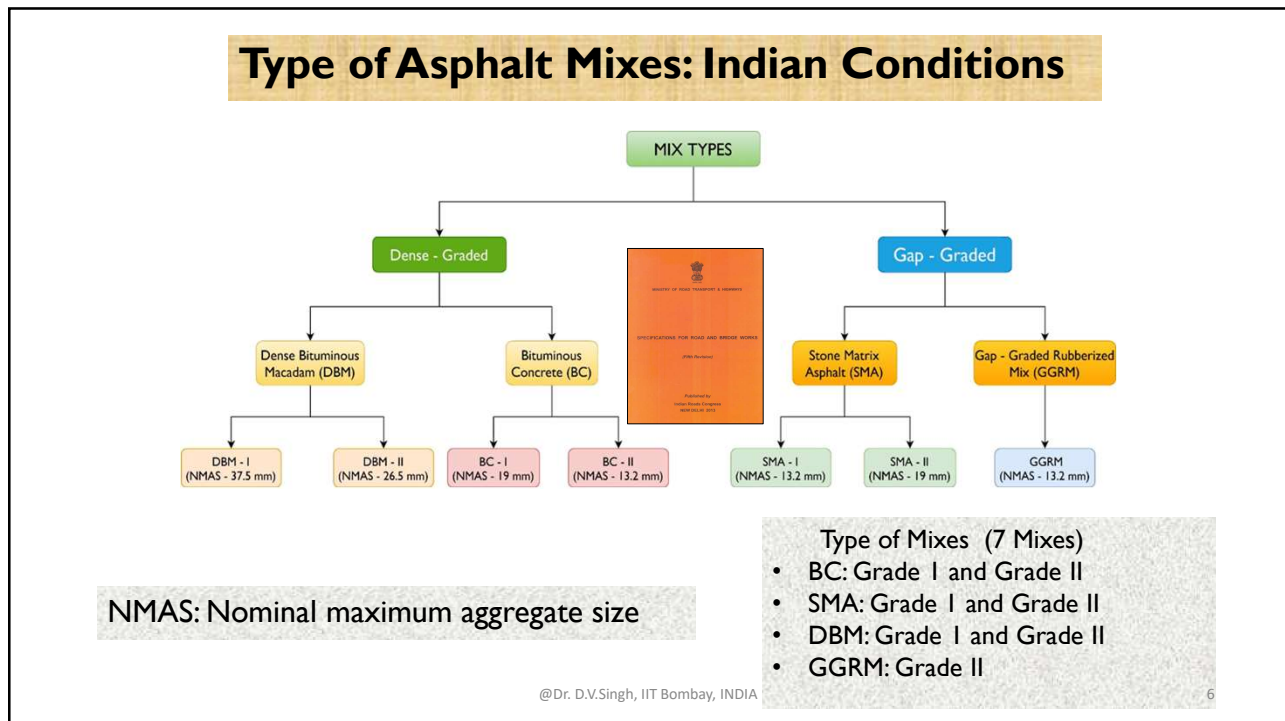
## Asphaltic Pavement



4

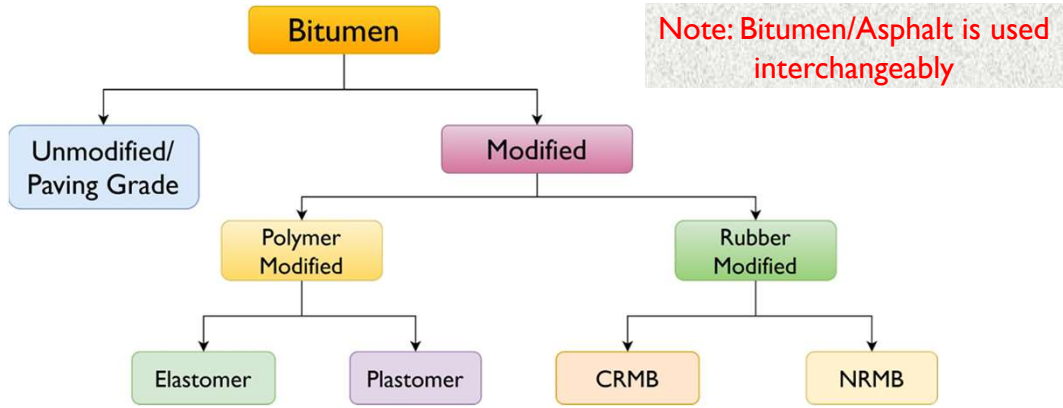


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6

## Types of Bitumen/Asphalt in India



Note: Bitumen/Asphalt is used interchangeably

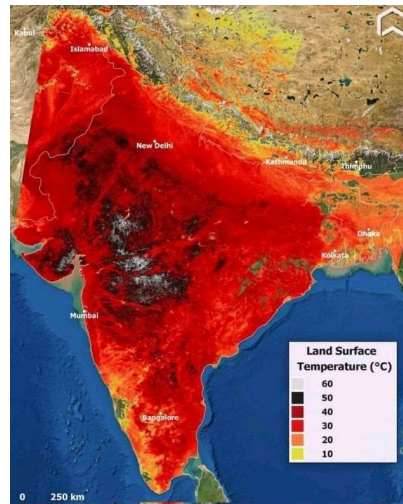
CRMB: Crumb rubber modified bitumen,  
NRMB: Natural rubber modified bitumen

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7

7

## Traffic and Climatic Conditions



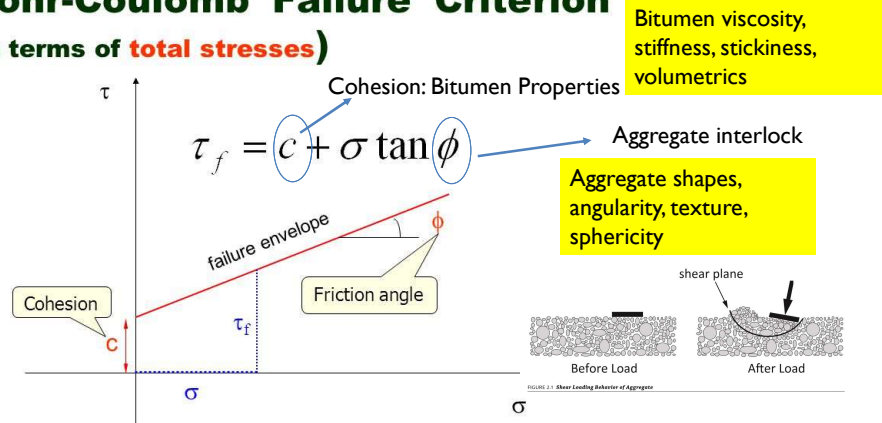
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8

8

# Shear Strength of Asphalt Mixes

## Mohr-Coulomb Failure Criterion (in terms of total stresses)



**Recycled material, Binder, Additives, Fibers, Plastic, Polymers, Rubber, Rejuvenators, Bio-binders**

Ref: MS-2 Asphalt Institute

9

9



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10

10



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11

### Balanced Mix Design (BMD)

A **Mix Design** is required which

- Using **performance tests**
- Address **multiple modes of distress**

Mix Aging

Traffic

Climate

Mix Position in Pavement Structure

Rutting

Cracking

▶

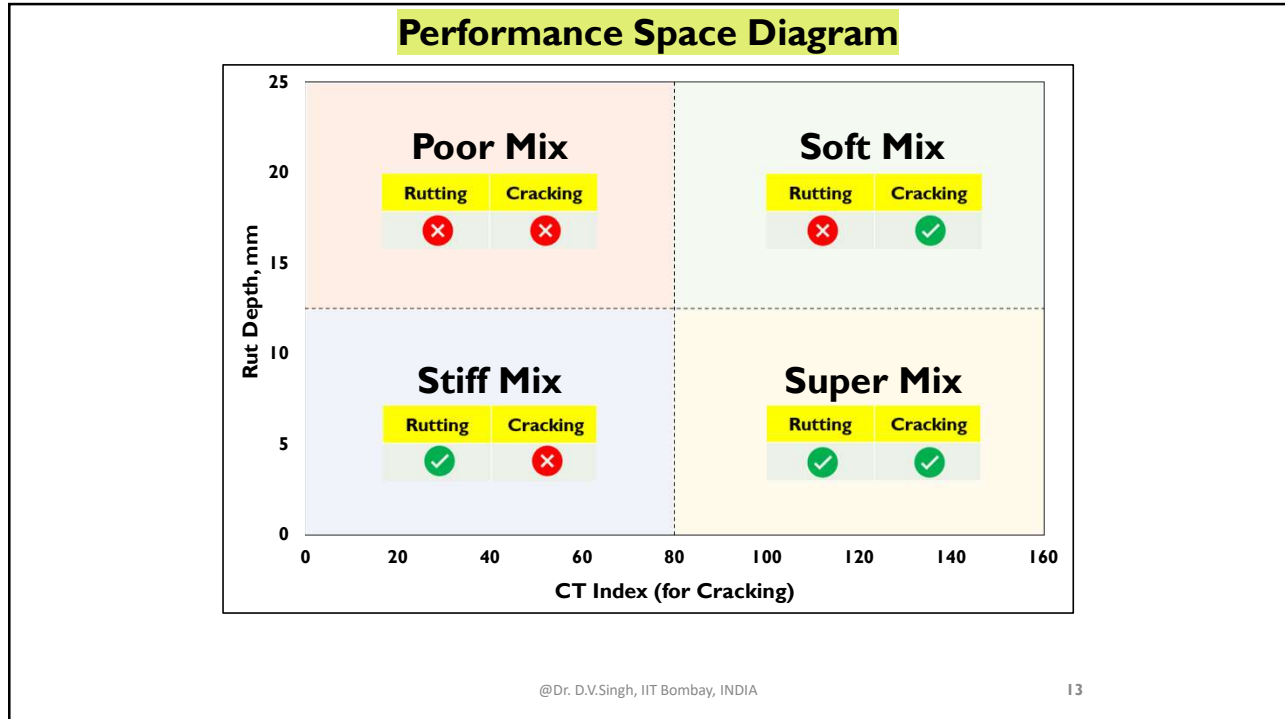
Design for Performance

Binder Content (%)	Rut Depth (mm)	CT Index
5.0	8.0	60
5.5	10.0	80
6.0	14.0	140

- Optimum Binder Content (OBC) : Lies in Acceptable AC Range + Check For **Moisture Damage**

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12



13

### Rutting in Asphalt Pavement

**Rutting** - Longitudinal surface depression in the wheel path

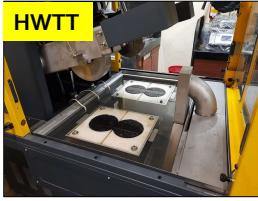
- Riding Quality
- Hydroplaning
- Road Safety
- High potential for traffic accidents

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14

## Laboratory Tests: Rutting Resistance of Asphalt Mixes

### HWTT



- 1 cut per specimen
- Total time: 2-3 days
- Sample Size: 150 mm Dia \* 62 mm H
- Wheel load: 705 ± 2 N
- Air void content: 7.0 ± 1.0%
- Test temperature: 50 ± 1°C

### APA



- No cut or gluing;
- Total time: 2-3 days
- Sample size: 150-mm Dia \* 75mm H
- Hose pressure: 0.69 MPa
- Wheel load: 445 ± 5 N
- Test cycles: 8,000
- Air void content: 7.0 ± 1.0%
- Test temperature: 50 ± 1°C

### Flow Number



- Coring and 2 cuts per specimen
- Testing time: 2-3 days
- Specimen Size: 150 mm Dia \* 100 mm H
- Load Stress: 600 kPa
- Air void content: 7.0 ± 1.0%
- Test temperature: 50 ± 1°C



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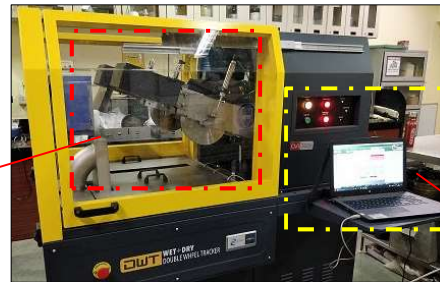
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15

## Hamburg Wheel Tracking Test (HWTT)

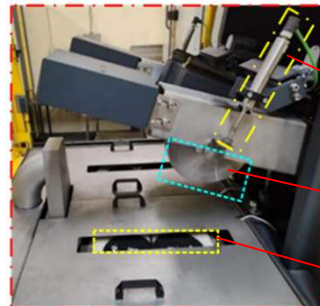
### Test Conditions

- AASHTO T 324
- Specimen Size: 150 mm Dia \* 65/95 mm H
- Wheel load: 705 ± 4.5 N
- Air void content: 7.0 ± 0.5%
- Test temperature: 60 ± 1°C
- Conditioning Time: 1 Hour (in Water)



Testing Chamber

Data Acquisition & Control Unit



LVDT

Steel Wheel

Loaded Sample

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16

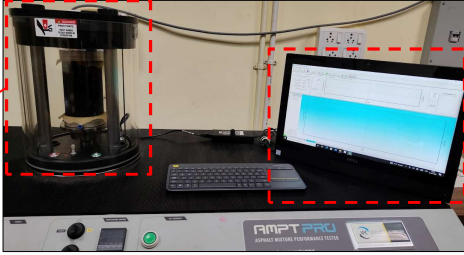
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### Flow Number (FN) Test

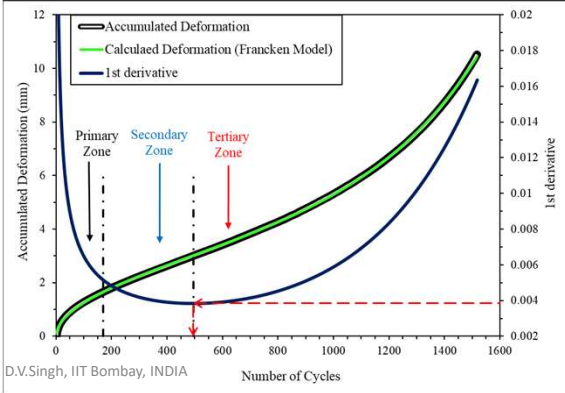
**Test Conditions**

- AASHTO TP 79
- Specimen Size: 100 mm Dia \* 150 mm H
- Axial Load: 600 kPa
- Air void content: 7.0 ± 0.5%
- Test temperature: 50 ± 1°C
- Conditioning Time: 4 Hour (Min.)



Testing Chamber      Control Unit & Data Acquisition






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17

### Limitations and Requirements


- **Cost:** Highly Expensive
- **Additional Machinery & Tools:** Saw Cutter and Core Cutter
- **Time:** Take significant time
- **Skilled Handling:** Required well expertise to run the tests
- **High maintenance cost**
- **Not practical for being used as QC testing**



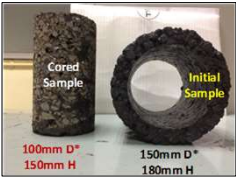
Saw Cutter



Core Cutter



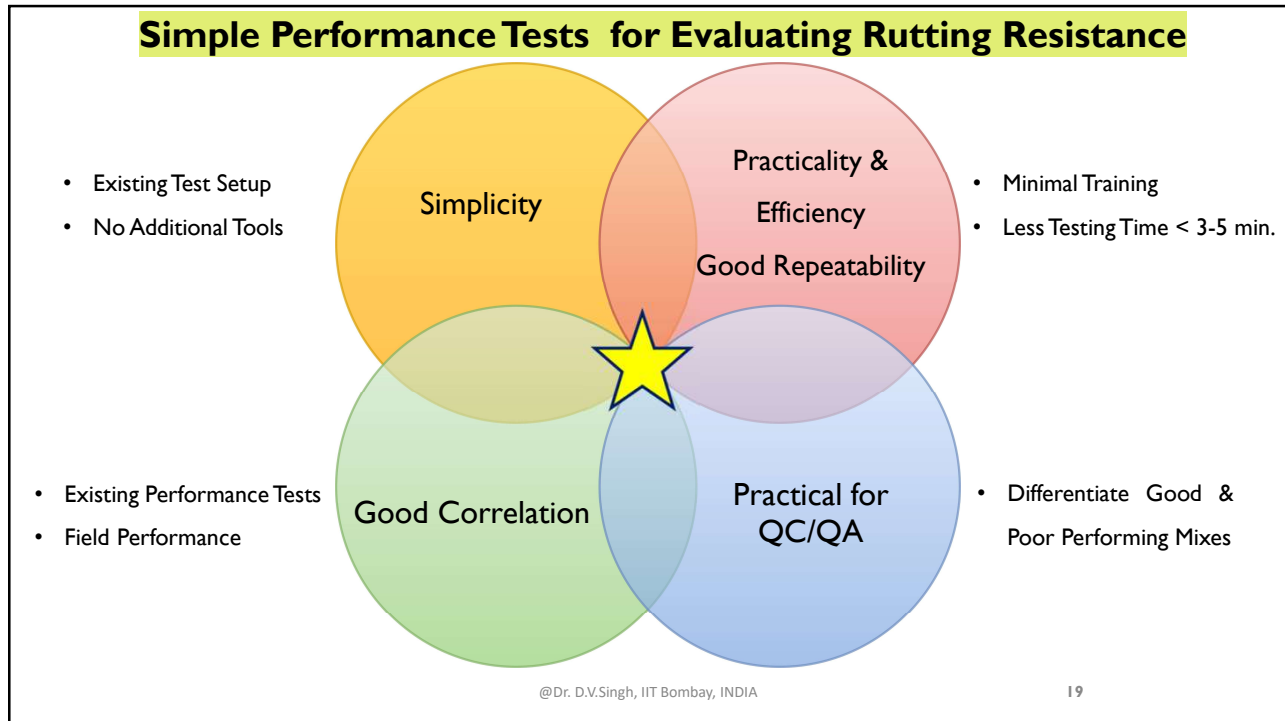
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**Limited Application**

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18



19

### Simple Performance Tests

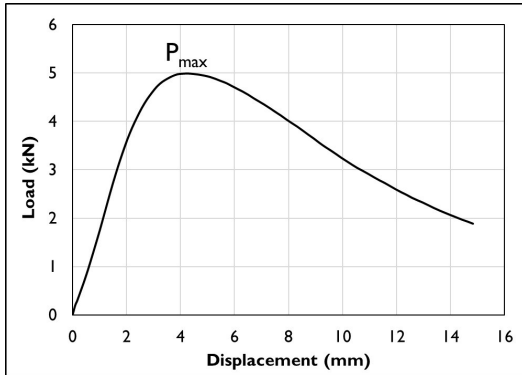
Author(s)	Test	Rutting parameter	Temperature (°C)	Sample Dimensions		Air Voids (%)	Loading Rate (mm/min.)
				Diameter (mm)	Height (mm)		
ASTM D6927 (ASTM 2022b)	MS	Marshall Stability	60	101.6	63.5	4	50
Christensen & Bonaquist (2002)	HT-IDT	IDT Strength	50	150.0	62.0 (NMA ≤ 19 mm) 95.0 (NMA ≥ 25 mm)	7	50
Zhou et al. (2019)	IDEAL-RT	Shear Strength RT <sub>Index</sub>	50	150.0	62.0 (NMA ≤ 19 mm) 95.0 (NMA ≥ 25 mm)	7	50
Kim et al. (2011)	Kim Test	Deformation Strength	60	100.0 150.0	63.0	4	30
Li et al. (2016)	AST	Slippage Energy Index (SEI)	60	100.0	65.0	7	20
Faruk et al. (2015)	SPST	Shear Strength	50	152.4	63.5	7	12

**MS** = Marshall Stability; **HT-IDT** = High Temperature Indirect Tensile Strength Test; **IDEAL-RT** = Ideal Rutting Test;  
**AST** = Aggregate Slippage Test; **SPST** = Simple Punching Shear Test; **NMA** = Nominal Maximum Aggregate Size.

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20

### Rutting Test: IDEAL-RT



- ASTM D8360
- Specimen Size: 150 mm Dia \* 65/95 mm H
- Loading Rate: 50 mm/min
- Air void content: 7.0 ± 1.0%
- Test temperature: 50 ± 1°C
- Conditioning Time: 2 Hour (Min.)

$$RT_{index} = \tau_f \times 6.618 \times 10^{-5}$$

$$\tau_f = 0.356 \times \frac{P_{max}}{t \times w}$$

$P_{max}$  : maximum load (N)  
 t: thickness of sample (m)  
 w: width of loading strip (m)  
 $\tau_f$ : Shear stress in (Pa)

$RT_{Index} \uparrow \rightarrow$  Rutting Resistance  $\uparrow$

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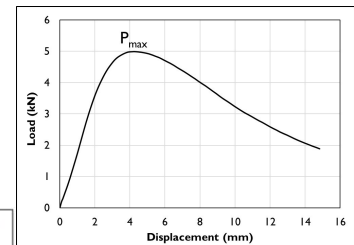
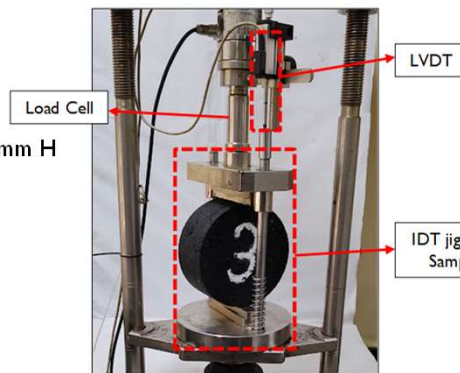
21

21

### HT-IDT (High Temperature-IDT)

#### Test Conditions

- Specimen Size: 150 mm Dia \* 65/95 mm H
- Loading Rate: 50 mm/min
- Air void content: 7.0 ± 0.5%
- Test temperature: 50 ± 1°C
- Conditioning Time: 2 Hour (Min.)



$$\sigma_{IDT} = \frac{2P}{\pi Dt}$$

$D$ : Diameter of sample  
 $T$ : thickness of sample  
 $\sigma_{IDT}$ : Indirect tensile strength  
 $P$  = maximum load

$\sigma_{IDT} \uparrow \rightarrow$  Rutting Resistance  $\uparrow$

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22

22

### Indian Practice – Bituminous Mix Design Method



Compacted Samples



Marshall Stability Test

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23

23

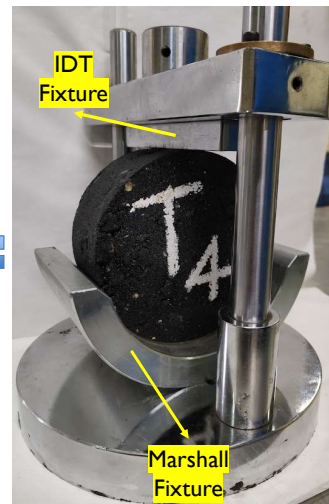
### Marshall Rutting Test (Marshall-RT)



Marshall Stability Setup



IDT Setup



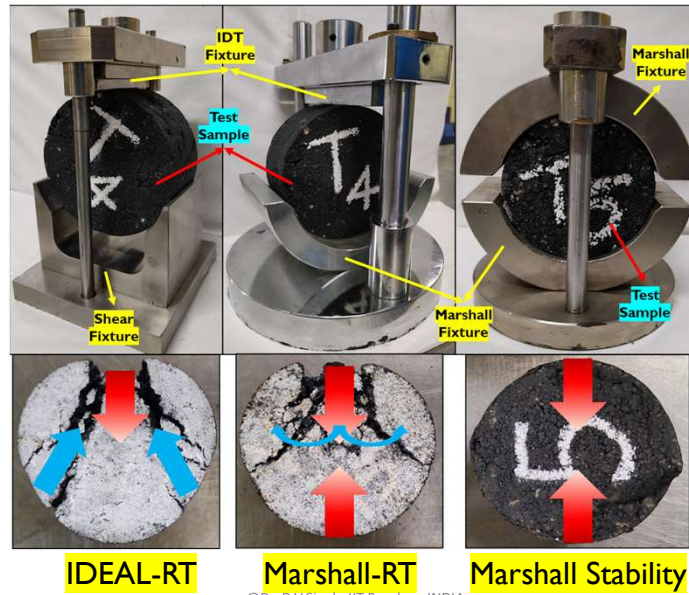
Marshall-RT Setup

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24

24

### Failure Pattern in IDEAL-RT, Marshall-RT and Marshall Stability



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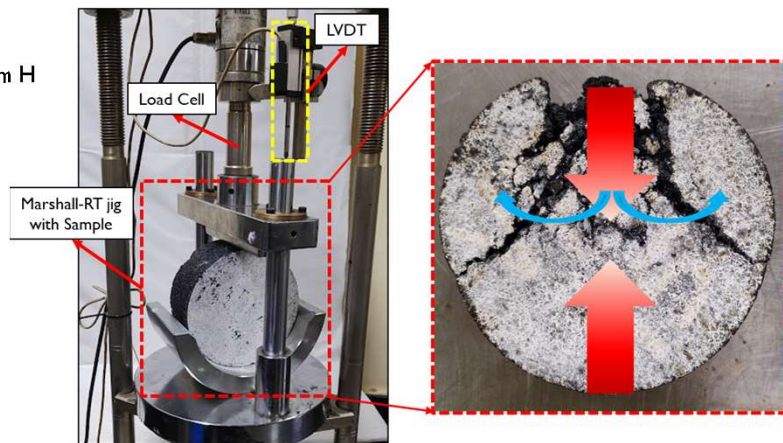
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25

### Marshall Rutting Test (Marshall-RT)

#### Test Conditions

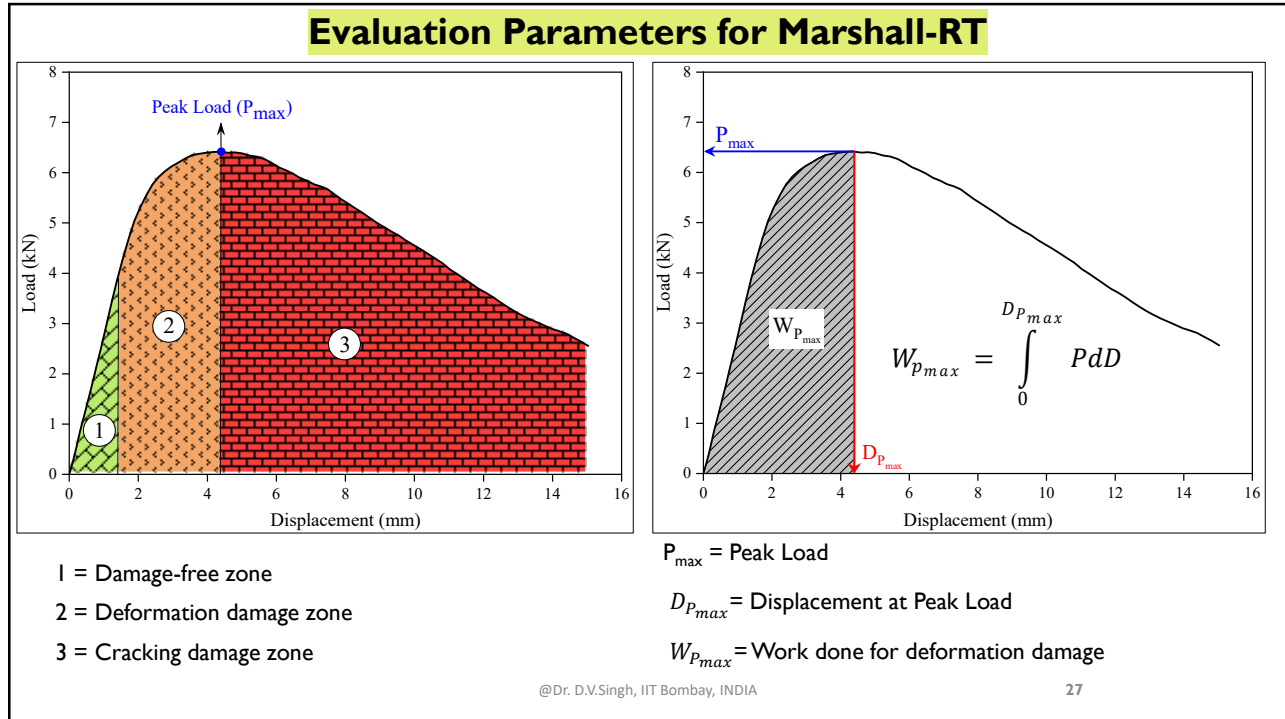
- Specimen Size: 150 mm Dia \* 65/95 mm H
- Loading Rate: 50 mm/min
- Air void content:  $7.0 \pm 0.5\%$
- Test temperature:  $50 \pm 1^\circ\text{C}$
- Conditioning Time: 2 Hour (Min.)



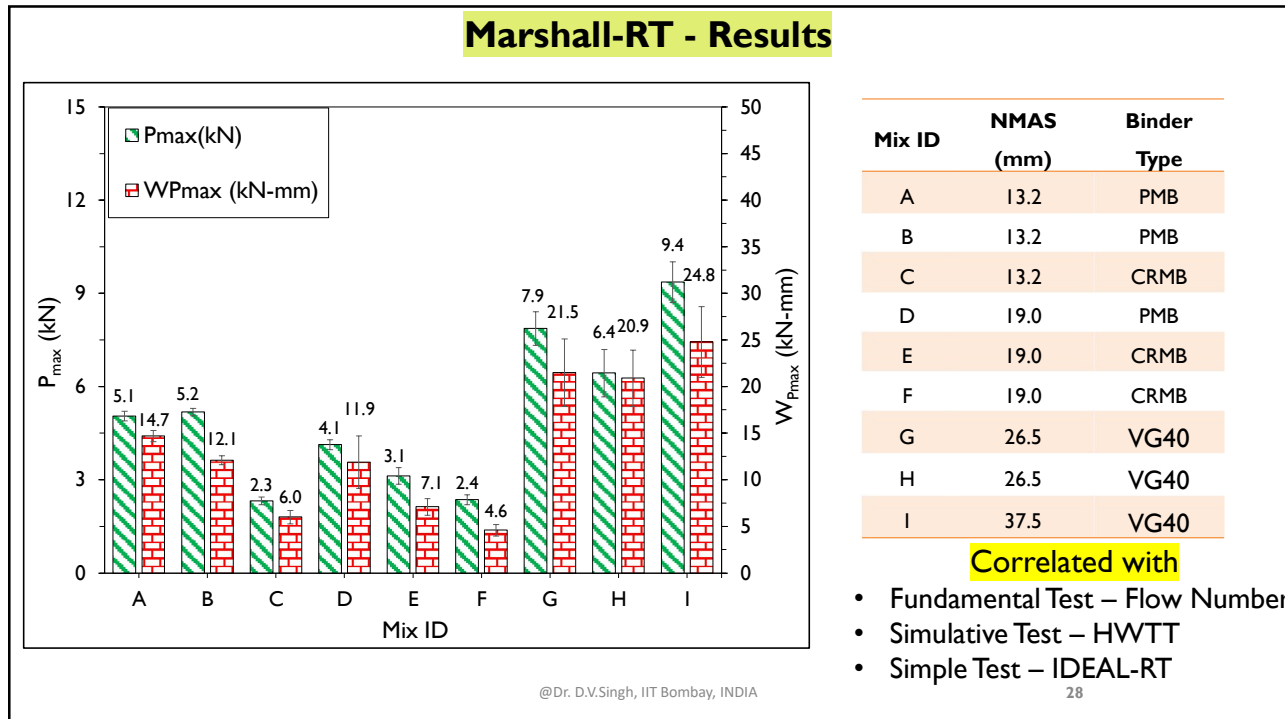
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26

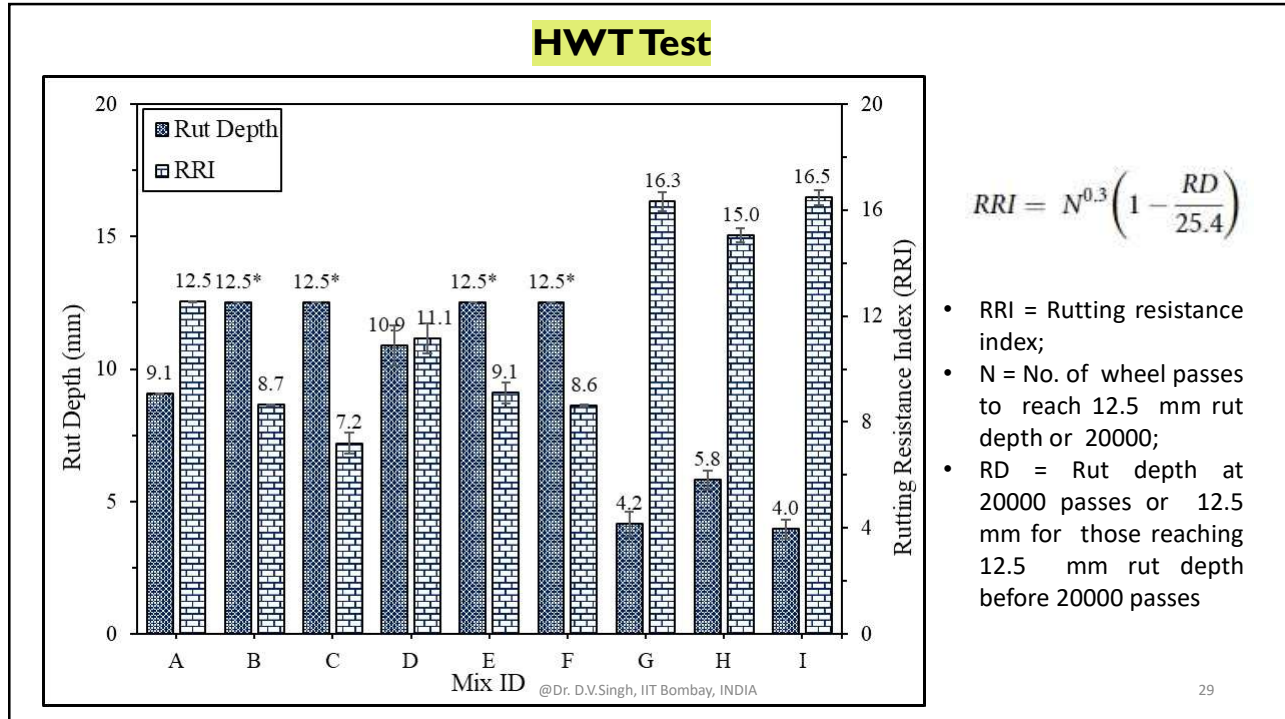
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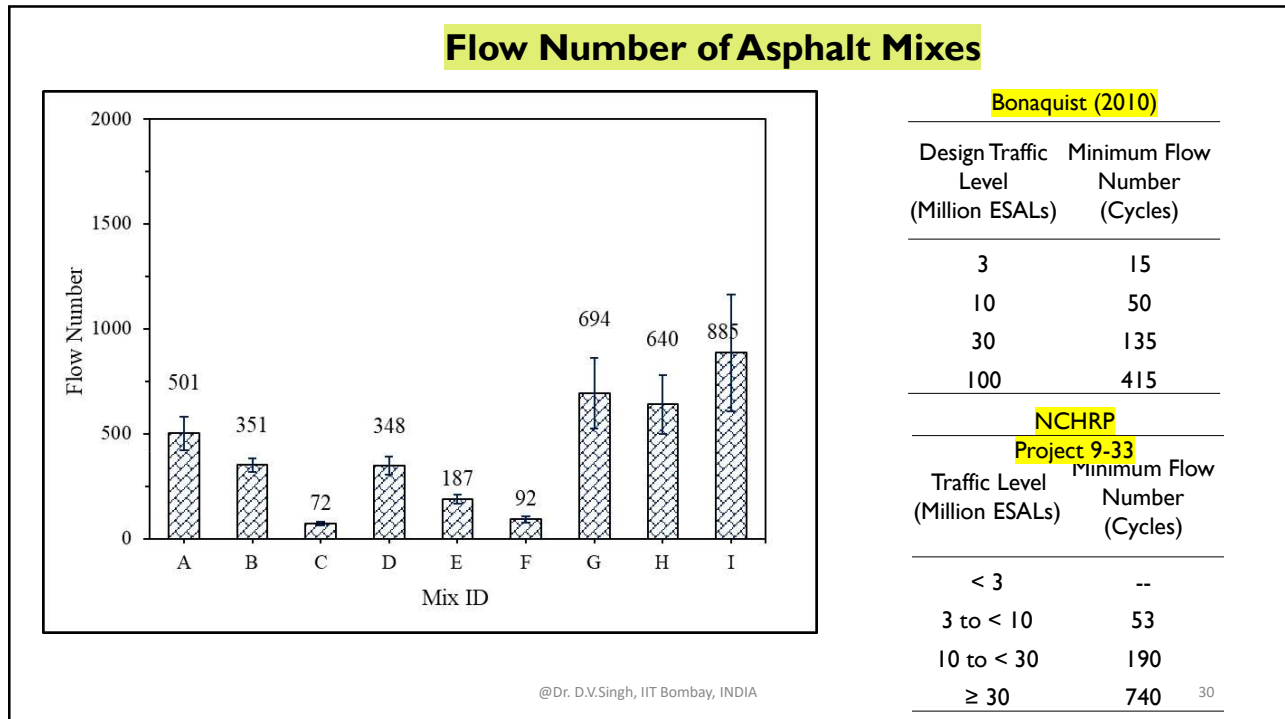
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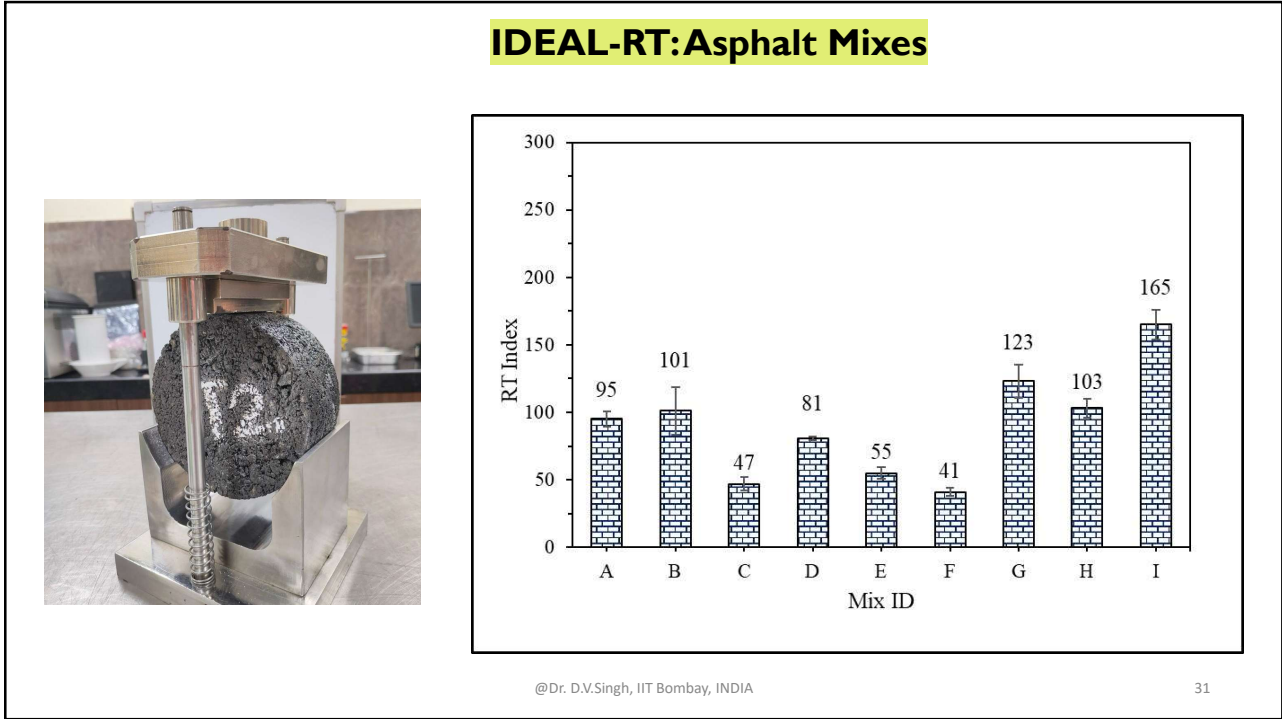
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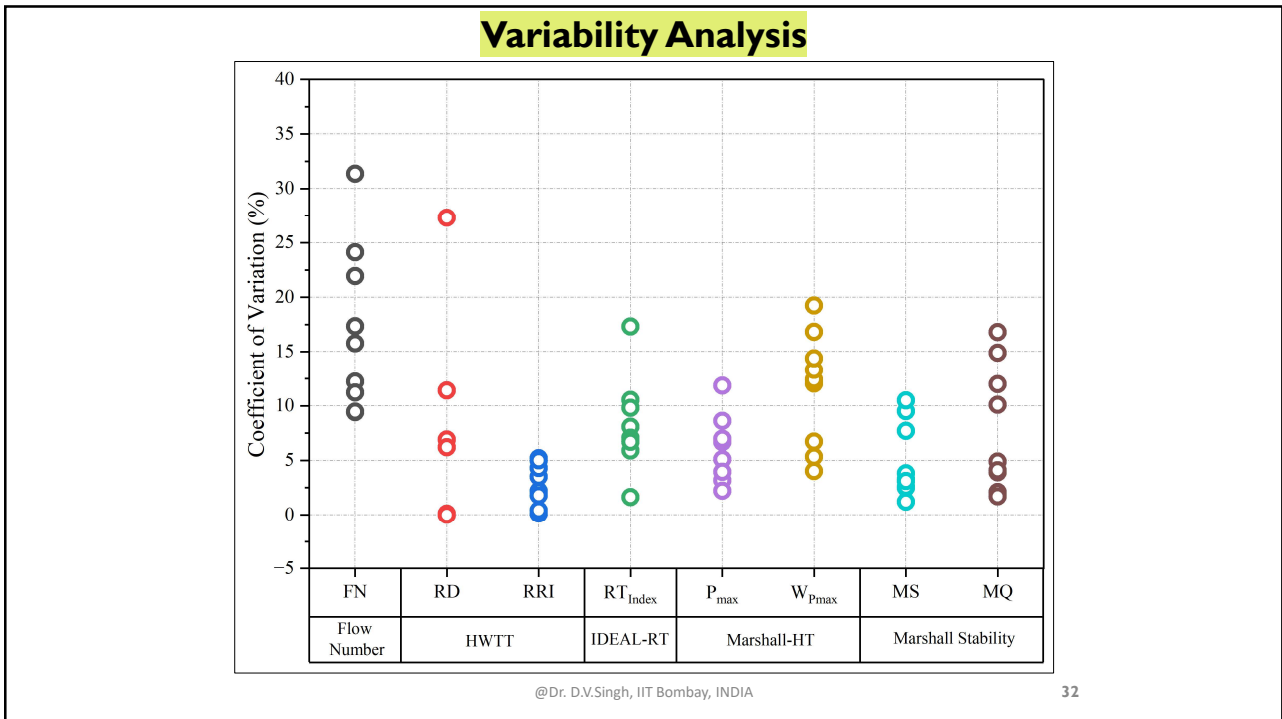
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30

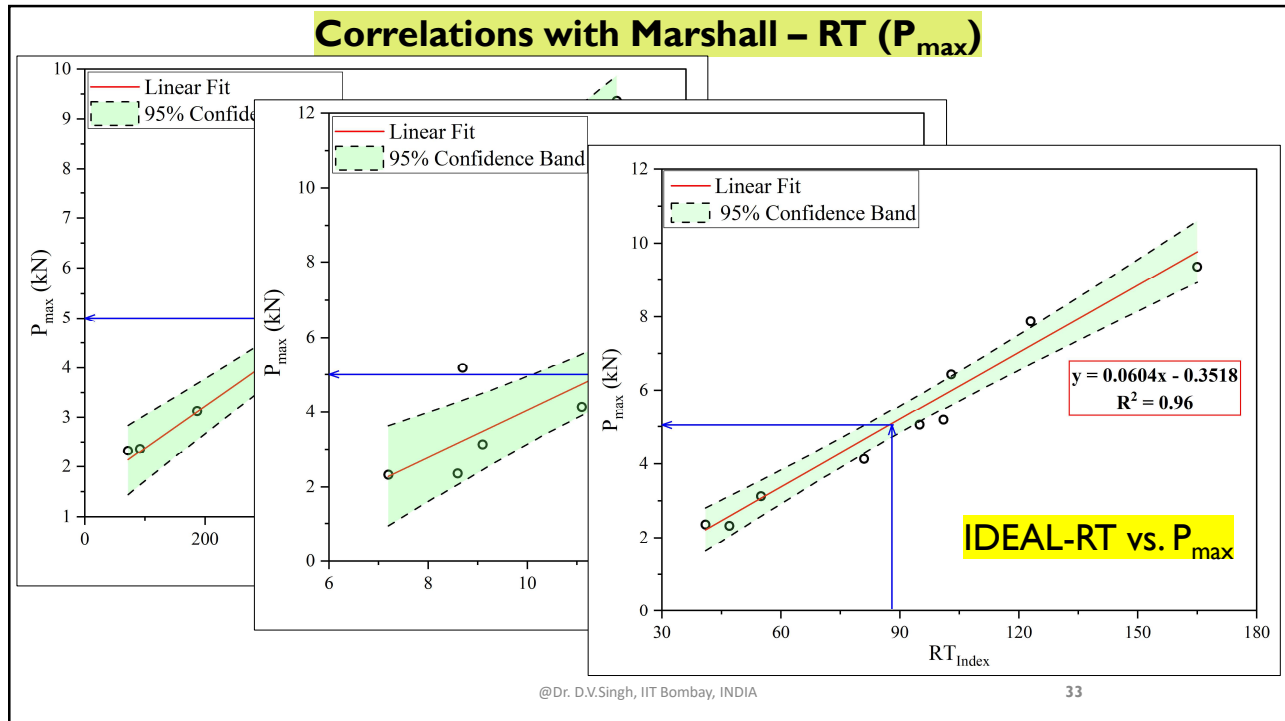


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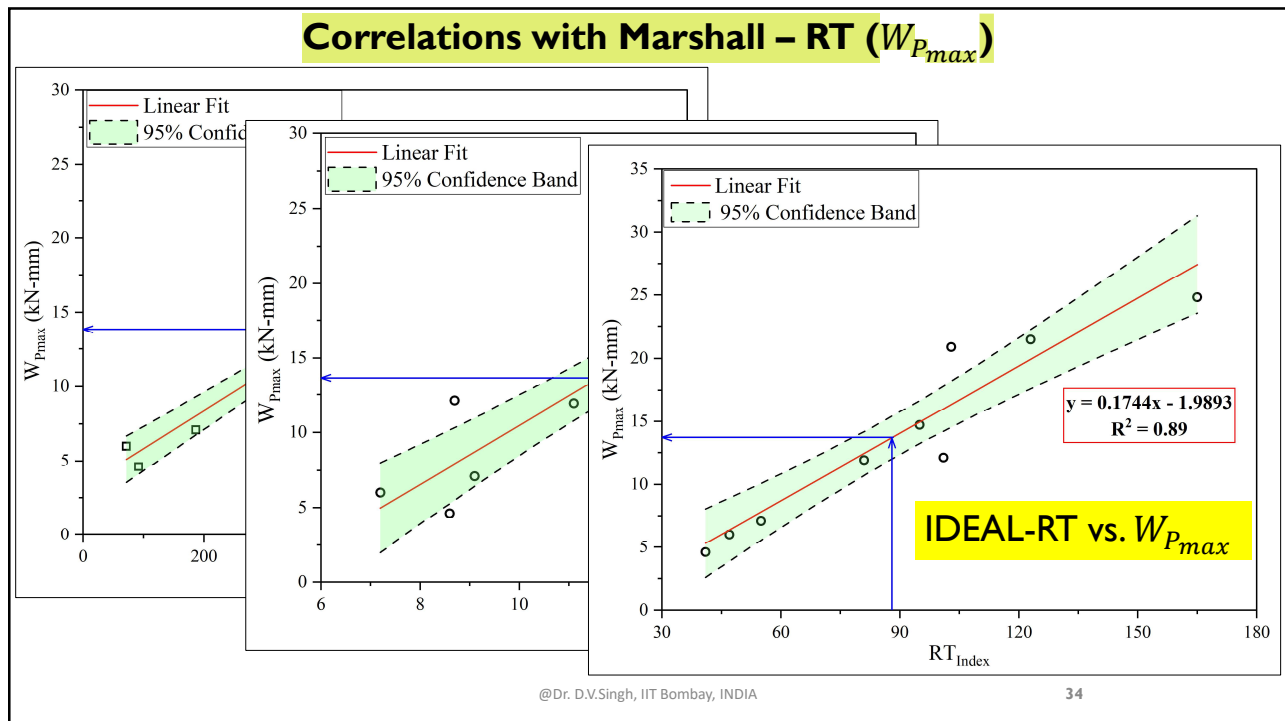


32





33



34


### Threshold Value Different Traffic Levels

	Design Traffic Level (Million ESALs)	Minimum Flow Number (Cycles)	HWTT		IDEAL-RT		Marshall-RT		Suitability of Collected Mixes
			RRI	Rut Depth (mm)	RT Index	$P_{max}$ (kN)	$W_{p_{max}}$ (kN-mm)		
Bonaquist (2010)	3	15	6.8	17	36	1.7	3	All Mixes	
	10	50	7.2	16	40	2.0	4	All Mixes	
	30	135	8.3	15	52	2.7	6	A, B, D, E, G, H, I	
	100	415	11.6	10	90	5.1	14	A, G, H, I	
NCHRP Project 9-33	< 3	--	--	--	--	--	--	All Mixes	
	3 to < 10	53	7.3	16	41	2.0	4	All Mixes	
	10 to < 30	190	8.9	14	59	3.2	8	A, B, D, E, G, H, I	
	≥ 30	740	15.6	5	133	7.8	22	I	

Test condition: HWT -60 C steel wheel, IDEAL-RT, Marshall-RT, Flow Number: 50 C (Air voids: 7+/-1%)

35

### Marshall Rutting Test (Marshall-RT)




Marshall Fixture

Marshall Fixture

**Marshall Stability Setup**

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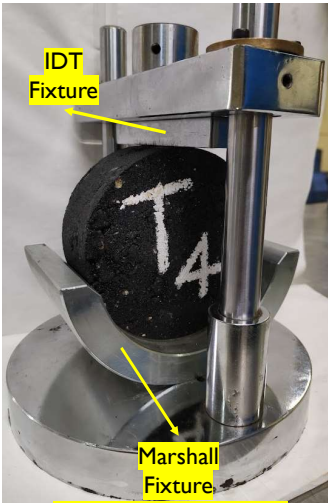


IDT Fixture

IDT Fixture

**IDT Setup**

=



IDT Fixture

Marshall Fixture

**Marshall-RT Setup**

The Marshall-RT test is a simple, practical, and efficient rutting test that can be performed using existing resources (available loading frames and the jigs in many laboratories) to evaluate the rutting resistance of asphalt mixtures.

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36



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# THANKS



*Dr. Zaman and family visit to India March 2019*