

# BIOMASS TO BIO-BITUMEN



**CSIR**  
**CRRI**



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# What is this Bio-Bitumen

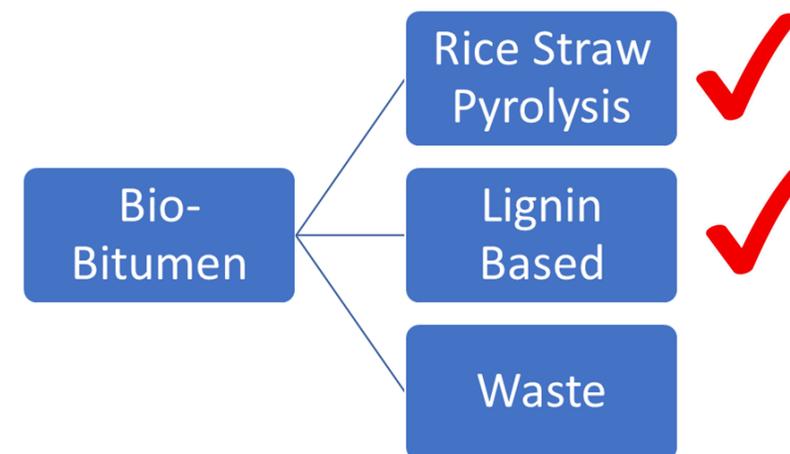
Bio-bitumen, an alternative to petroleum-bitumen which is produced using renewable organic materials.

Category	Examples
Agricultural Biomass	<b>Lignin</b> , sugarcane, <b>rice straw</b> , oil crops, <b>corn stalks, juliflora</b>
Waste Materials	MSW, food waste, used cooking oils
Algae and Aquatic	Microalgae, seaweed
Natural Resins	Gum rosin, plant pitch
Animal By-products	Tallow, fish oils
Forestry Residues	<b>Wood chips</b> , tree bark
Wastewater and Sludge	Sewage sludge, wastewater algae

PROCESSES:  
Thermal Pyrolysis  
Hydrothermal Liquefaction  
Fermentation & Polymerisation  
Extraction from Natural Resins  
Algal Processing  
Lignin- thermochemical treatment



**A Bitumen :-  
Economical,  
Sustainable &  
Durable**

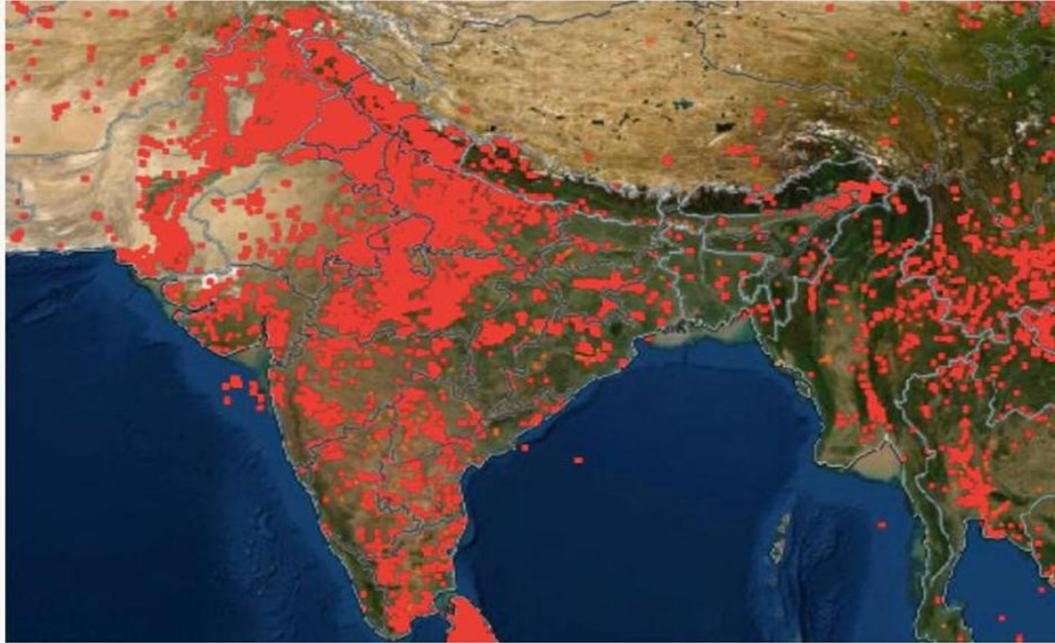


The choice of method depends on feedstock availability, energy requirements, cost-effectiveness, and the desired properties of the final product i.e Bitumen.

# THE PROBLEM: Bitumen Shortage & Rising Pollution

☰ Fire Points in India

View in Detail

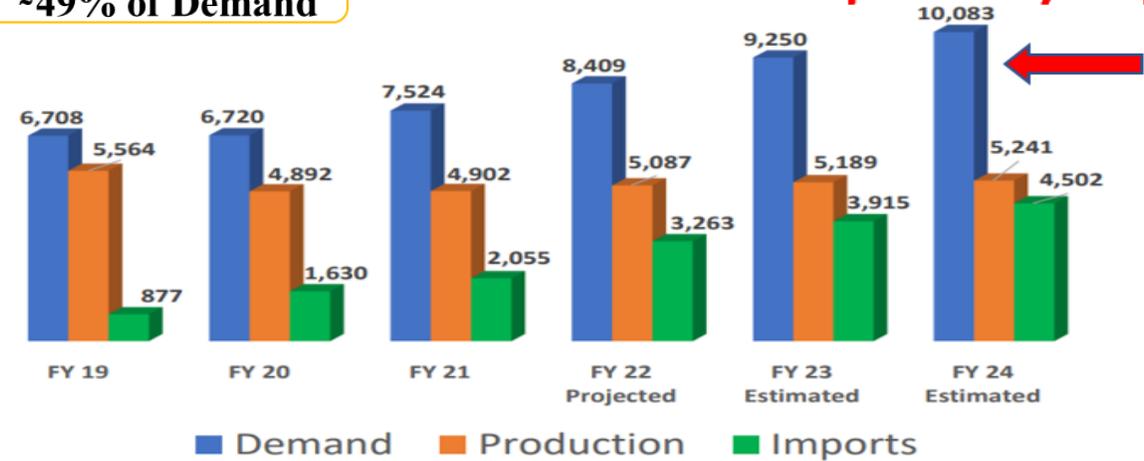


## STAGNANT DOMESTIC PRODUCTION

Bitumen Imports  
~49% of Demand

figures in '000 mt

**Increasing Supply Gap met by Imports**



**ESTIMATED ANNUAL IMPORT COST: 25000 CRORES**



# THE SOLUTION : BIO-BITUMEN

Up to 30%  
replacement of  
conventional  
Bitumen

CSIR-CRRI & IIP developed the process to produce bio-bitumen by doing pyrolysis of rice straw. The produced bio-bitumen was extensively tested by CRRI on all the performance parameters of a National Highway



**World's First Field Trial of Bituminous Surface Layer with Bio-binder produced from Rice Straw/ Biomass Pyrolysis**

**Trial stretch on Jorabat to Shillong (Barapani) section of NH-6 (Old NH-40)**

**26<sup>th</sup> October 2024**

**Technology Patent Filed  
(Application no:202411063553)**

# Bio-Bitumen

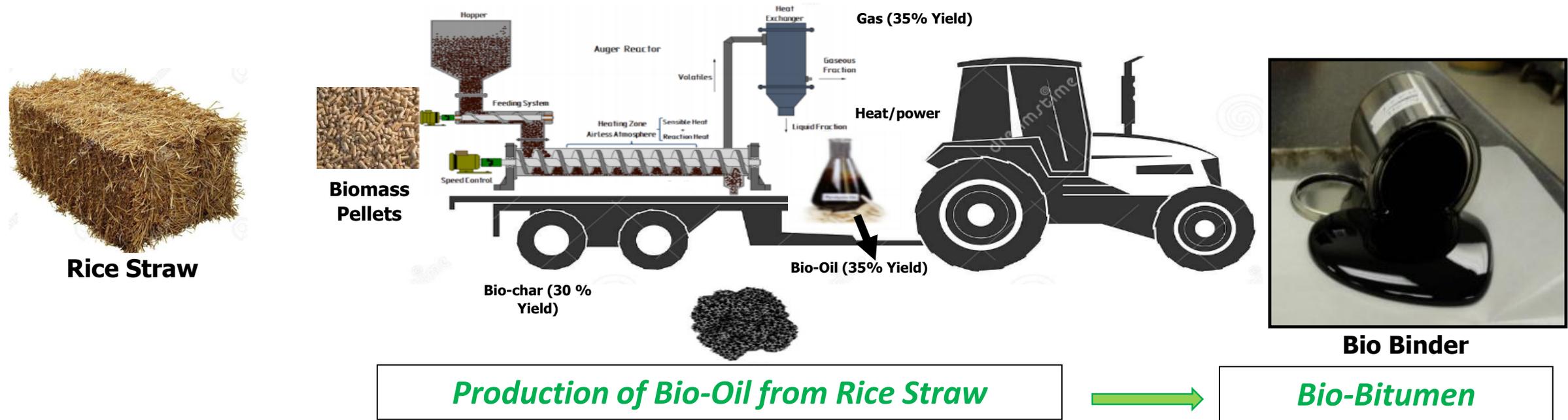
- Out of 200 MMTPA estimated surplus crop residues, ~40 MMTPA is enough to meet 4 MMTPA binder demand gap.
- Due to large variability in crop types and their productivity, there is a need to understand the spatio-temporal patterns of biomass.
- Needs location specific strategy for managing surplus crop biomass and the establish processes for bio-bitumen production units.

## Bio-Bitumen: Rice Straw-Pyrolysis



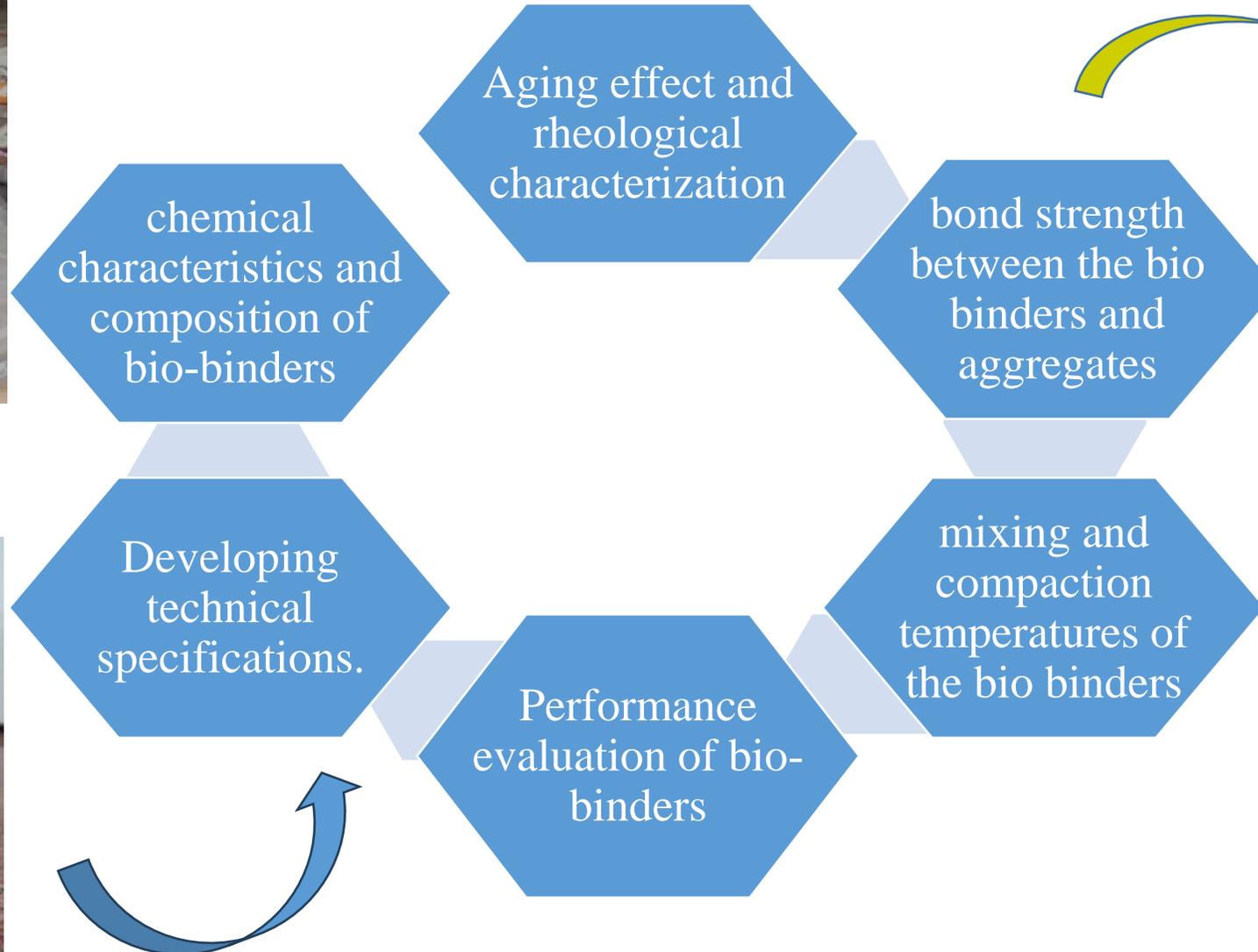
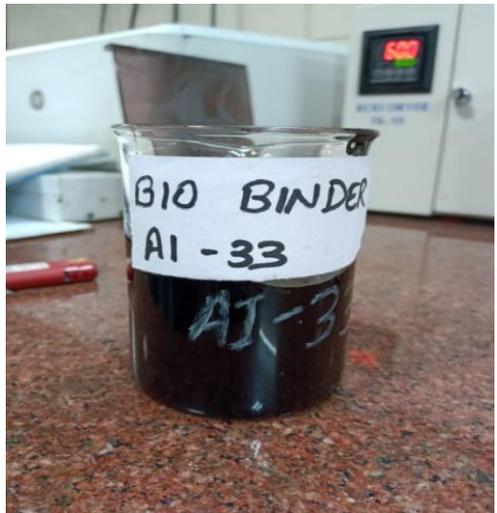
*CSIR-CRRI & IIP developed the process to produce bio-bitumen by doing pyrolysis of rice straw.*

# Production of Bio-Bitumen



- Pyrolysis of rice straw was performed at high temperature for production of bio-oil.
- The biochar, bio-oil and gaseous products are 30, 35 and 35 wt.% respectively.
- **Bio-oil was then processed by a series of chemical unit operations for production of bio-binder/bio-bitumen.**

# Developed Bio-bitumen from biomass to supplement petroleum-based bitumen for bituminous road construction



# Chemical Properties: SARA Analysis

- SARA Analysis of pure bio-bitumen and petroleum Bitumen are performed.
- The following table indicates the Average weight percentage of Bitumen components present in bio-binder and bitumen samples.



Sample	Saturates,%	Aromatics, %	Resins,%	Asphaltenes, %
<b>VG 40 (conventional petroleum based bitumen)</b>	<b>15.93</b>	<b>31.36</b>	<b>44.34</b>	<b>8.37</b>
<b>Bio-Bitumen (30% replacement)</b>	<b>14.12</b>	<b>36.47</b>	<b>41.46</b>	<b>7.95</b>

# Different Bio-oils were Produced & Evaluated

## Softening Point

Softening point of VG 40 (V) – 53.9 °C  
Base material (Z) – 73.9° C

Sample name	AI – 24	AI - 33
V- 10%	47.1°C	49.15°C
V- 20%	44.25°C	40.9°C
V- 30%	37.6°C	41.85°C
Z- 10%	65.85°C	60.5°C
Z- 20%	52.7°C	54.8°C
Z- 30%	51.9°C	45.7°C

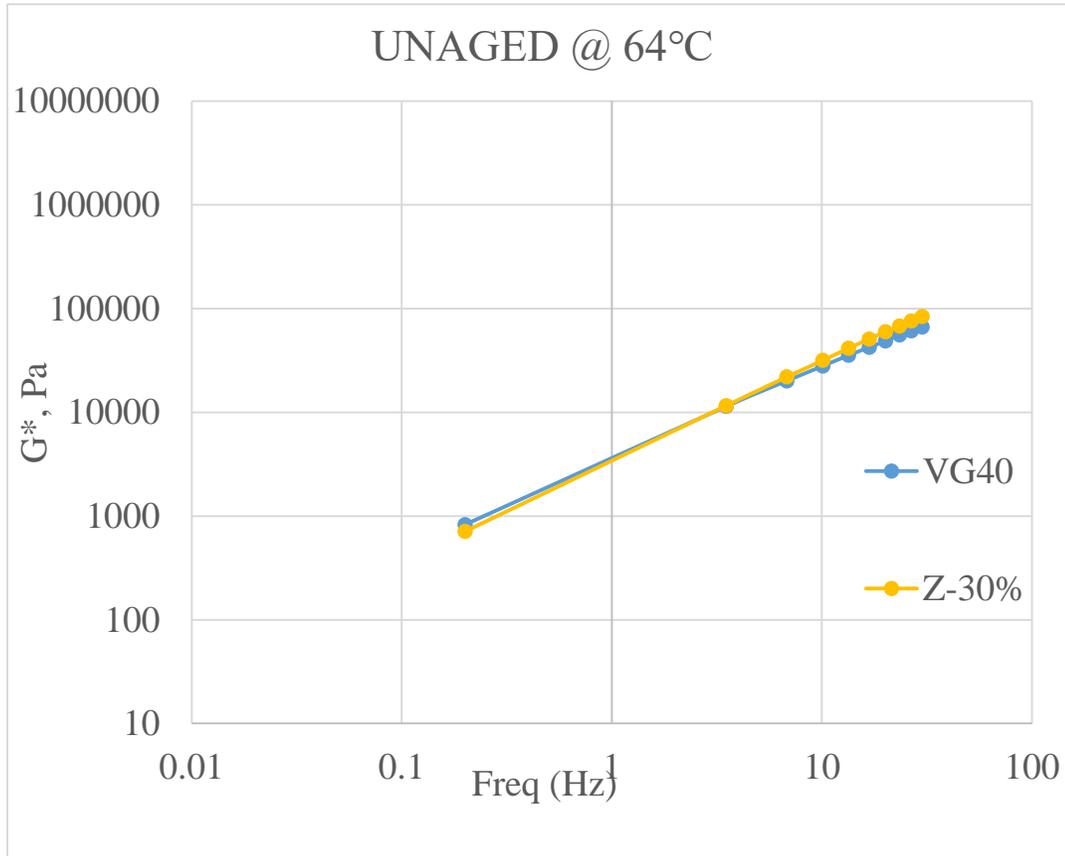


## Complex Modulus

Complex Modulus of VG 40 (V) – 9770 Pa  
Base material (Z) – 178000 Pa

Sample name	AI – 24	AI - 33
V- 10%	2380	7890
V- 20%	1150	3380
V- 30%	698	716
Z- 10%	34500	30100
Z- 20%	10200	7560
Z- 10%	5520	3600

# Bio Binder: Rheological properties



**Complex modulus using Dynamic shear Rheometer (DSR)**



# Bio-Bituminous Mix Evaluation

- Samples Prepared using Marshall Compactor
- BC-I: 5.2% Binder Content
- The coating and strength of bio-bitumen is found similar as conventional bitumen



Aggregates coated with bio-bitumen



# Performance Evaluation of Bio-Bitumen Mix



**Strength: ITS Test**



**Design Parameter: Resilient Modulus**



**Rutting: Dynamic Creep**

Type of Mix	Indirect Tensile Strength (kPa)		Tensile Strength Ratio (%)	Resilient Modulus, MPa @ 35 ° C	Permanent Axial Strain, % 50 ° C
	Dry	Wet			
Conventional VG 40	1105	1002	90.7	3350	1.80
Bio-Bitumen ( 30% replacement)	1050	962	91.6	3400	1.79

# Moisture Resistance: Stripping Test



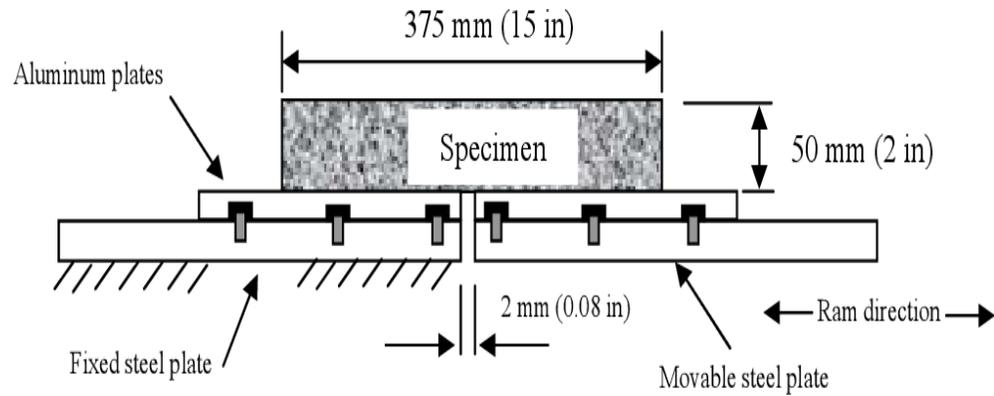
**VG-40 COATED AGGREGATES  
AFTER BOILING: 99.7% Coating**



**BIOBINDER COATED AGGREGATES  
AFTER BOILING: 99% Coating**

*Coating % estimated by Image Analysis*

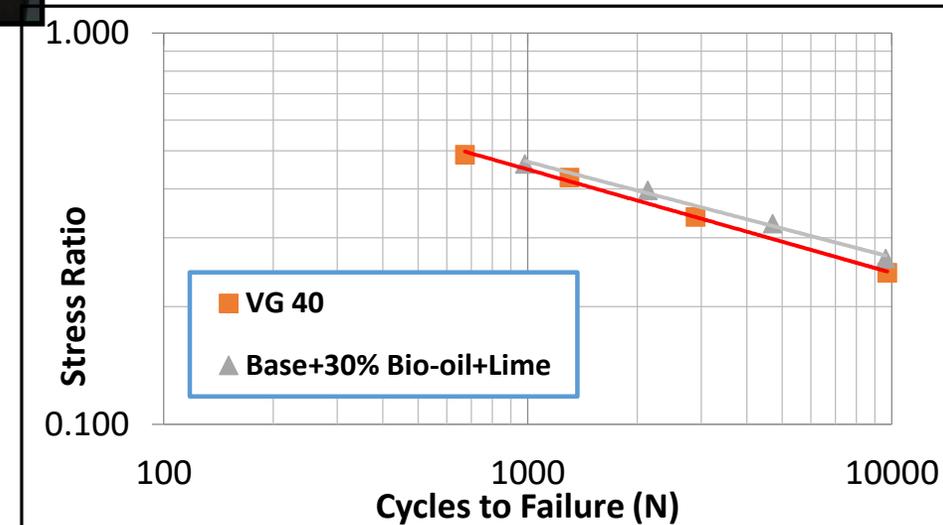
# Overlay Tester and Indirect Tensile Fatigue Test



Loading Pulse : Haversine  
 Control mode : stress  
 Stress levels : 4  
 Temperature : 25° C  
 Frequency : 1 Hz  
 Termination criterion : 9 mm deformation or sample failure

Type of Mix	No of Cycles to Failure, 25°C (Avg of Six Samples)
VG 40	210
BioBitumen 30% replacement	225

Reflective Cracking Resistance



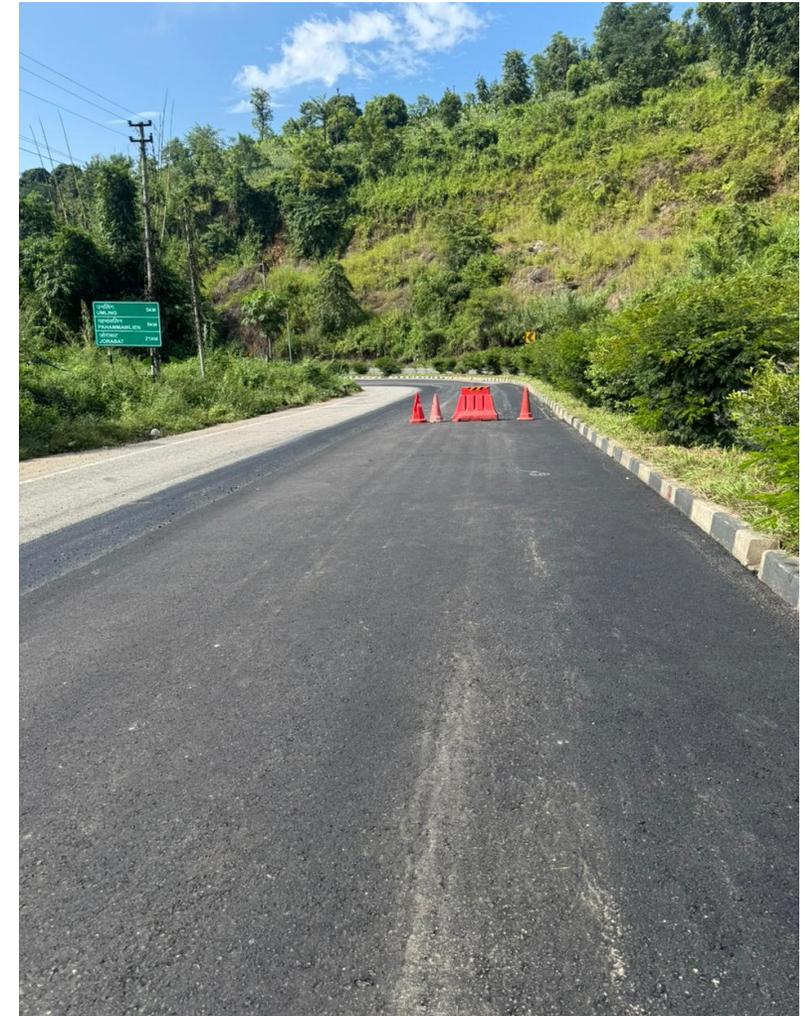
# Discussions with MoRTH on Bio-Bitumen Project



# Trial Section: Jorabat Shillong Expressway (NH-40)



✦	Test Section Details
🏠	Type: <b>Bituminous Concrete</b>
🚛	Trial section length – 100m
🚚	on RHS of <b>Jorabat Shillong Expressway (NH-40)</b> in the
🏗️	state of Meghalaya



## Smart , Innovative Technology adoption

### BENEFIT TO FARMERS

### REDUCED IMPORT COST OF BITUMEN

### DECARBONIZATION- NET ZERO AIM OF INDIA

This innovation will support global sustainability goals by generating revenue for biomass, mitigating stubble burning, and cutting greenhouse gas emissions by at least 70% compared to fossil-based bitumen. Leveraging abundant lignocellulosic biomass, it aligns with India's vision for sustainable industrial growth

- CRRRI's laboratory and filed trials have shown 30% replacement of fossil based bitumen with bio-bitumen.
- If India starts replacing even 15% of conventional fossil-based bitumen with bio-bitumen, the country can save at least Rs 4,000–4,500 crores annually.
- Cost of conventional bitumen is approx. 48-50 Rs per Kg, cost of bio-bitumen will be around 45 Rs per Kg
- Farmers will get values for the crop residue.
- Stubble burning can be stopped which will resolve environment pollution.
- Stubble burning leads to soil degradation, which pose a major hurdle to sustainable agriculture. By adopting bio-bitumen production technology soil nutrients can also be maintained which will empower farmers.

On 7/01/2026 TECHNOLOGY TRANSFER EVENT  
**“BIO-BITUMEN: FROM FARM RESIDUE TO ROADS”**  
 AN INNOVATION BY CSIR-CRRI & IIP





**CSIR**  
**CRRI**

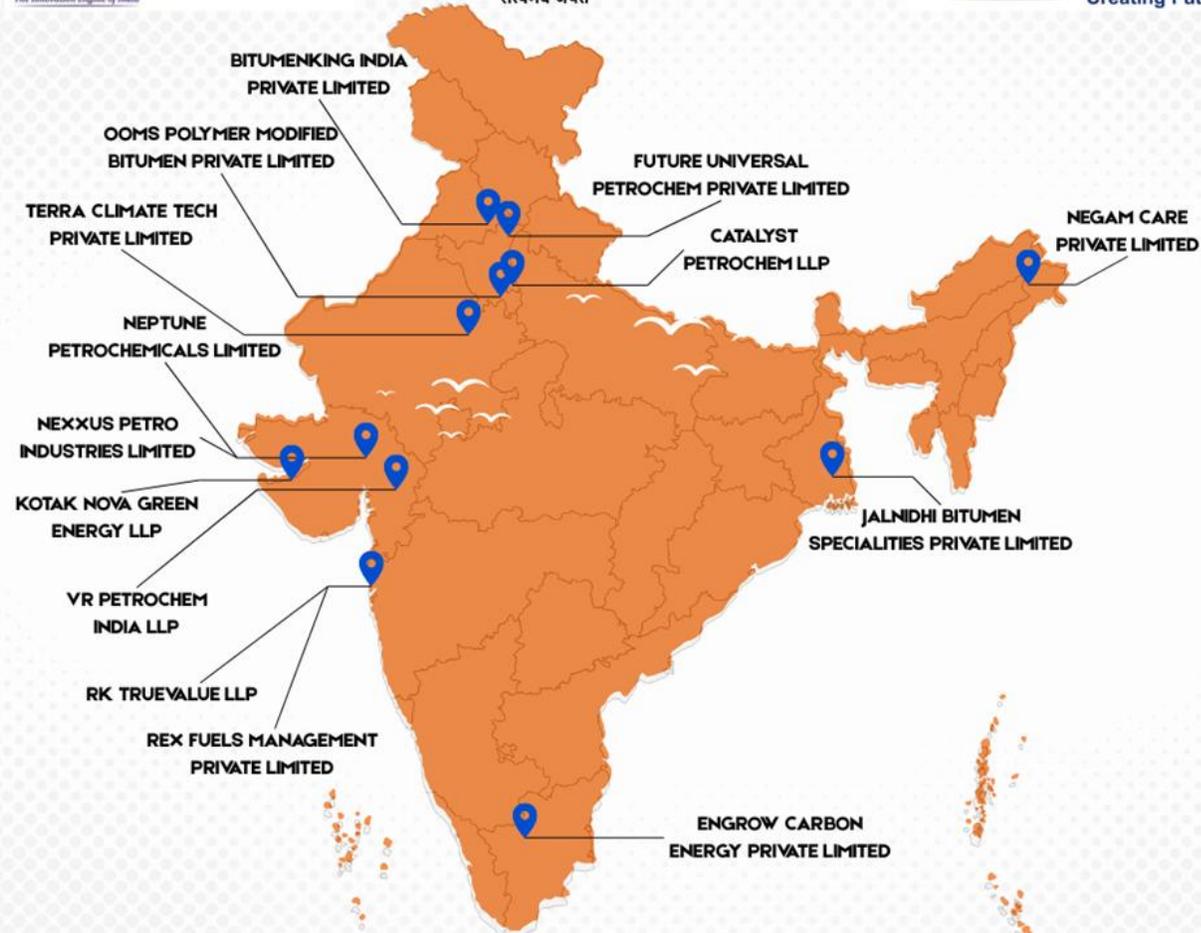


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प्रौद्योगिकी मंत्रालय  
MINISTRY OF  
SCIENCE AND  
TECHNOLOGY

सत्यमेव जयते



Creating Future Fuels



## INDUSTRY PARTICIPATION MAP

TECHNOLOGY TRANSFER EVENT

“FROM FARM RESIDUE TO ROADS: BIO-BITUMEN VIA PYROLYSIS”

AN INNOVATION BY CSIR-CRRI & CSIR-IIP

- Development of Bio-binder for construction of Flexible Pavements, CSIR -CRRI and CSIR-IIP. (Funding: CSIR, FTT Project)
- Development of Bio binders from Agricultural Waste for Utilization in Bituminous Road Construction, CSIR -CRRI and CSIR-IIP (Funding: Ministry of Road Transport and Highways).
- Dr. Ambika Behl, Dr. Rajiv Kumar, Dr. G. Bharath, Ms Anupriya “Laboratory Investigation of Lignin as An Alternative Extender to Bitumen for Asphalt” at the Global Road Construction Conference in December 2024.
- M Verma, G Bharath, A Behl, T Bhaskar, V Kakade, J Kumar (2023). Performance Evaluation of Bio-Binder Prepared with Rice Straw Bio-Oil. Canadian Journal of Civil Engineering, Vol. 50, Issue 12. [doi.org/cjce-2022-0467](https://doi.org/cjce-2022-0467)

CRRI received the Special Jury Award from the Hon'ble Minister of State for Road Transport & Highways, Shri Harsh Malhotra, under the **Build India Infra Awards** for Innovative Technology for the Bio-Bitumen Project.

Dr. Ambika Behl, Dr. Rajiv Kumar, Dr. G. Bharath, Ms Anupriya received the **Best Research Paper** Award at the Global Road Construction Conference in December 2024

CSIR-Central Road Research Institute has been shortlisted as a nominee to the Equipment and Manufacturing Award for the project "Development of Bio-Bitumen from Pyrolysis of Lignocellulosic Biomass, **IRF World Congress 2024**, Istanbul, Turkey

Dr. G. Bharath and Dr Ambika Behl received the **Best Technology Award** for the development of a biobinder for road construction at the Global Road Construction Conference in December 2024.



# THANK YOU