# Revolutionizing Road Infra with Modern Equipment, Technologies, Sustainable Materials and Policy Guidelines

*February 29th - March 1st, 2024, Manekshaw Centre, New Delhi*

## Sustainable Materials: Bio-Bitumen

## *CO2 SOURCE TO CO2 SINK*

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International Road Federation
India Chapter

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# CARBON EMISSION PROFILE OF CONSTRCUTION SECTOR

**Construction & Operations Account for...**

**36%**
the largest share of global final
**energy use**

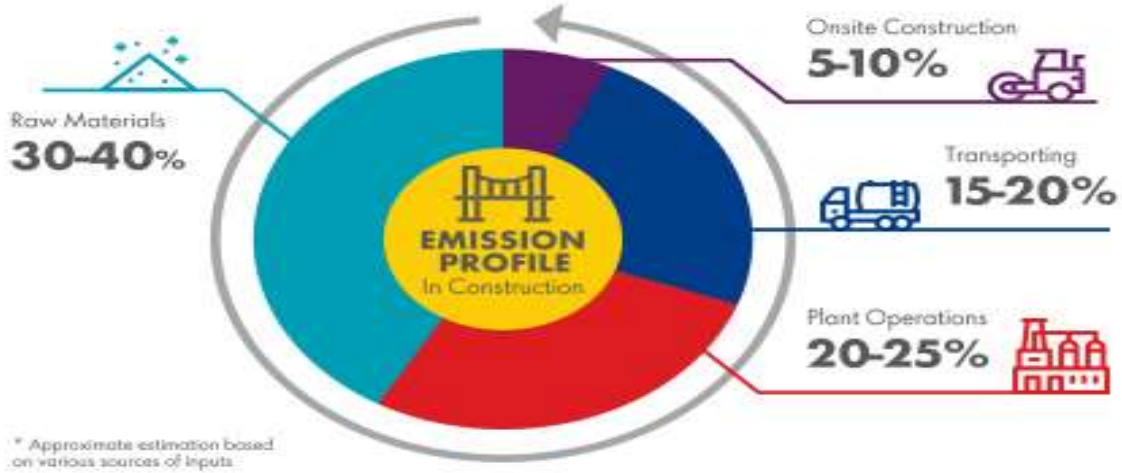
**37%**
...and energy related
**$CO_2$ emissions**

Source: UN Environment Programme 'Global Status Report for Buildings and Construction' October 2021

**Key sector Challenges:**

- Low productivity
- Low margin
- Increasing sustainability-related pressures

**Net-zero construction requires decarbonisation of...**




* Approximate estimation based on various sources of inputs

# Challenges Ahead: Road Construction Sector

## Rapidly rising depletion of Raw Materials (Bitumen & Aggregates)

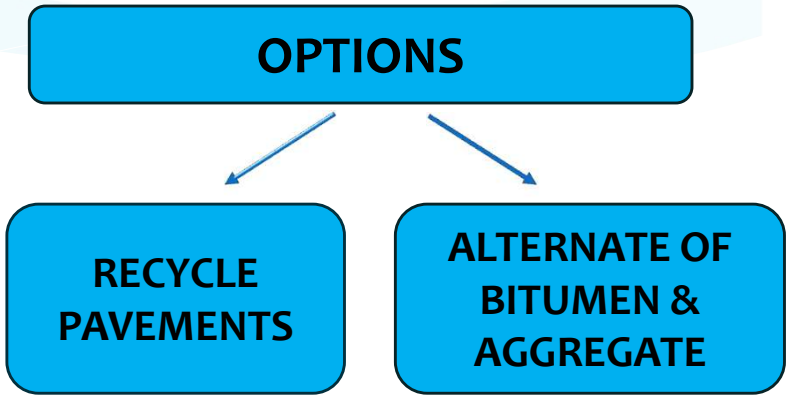
- **20,000 Ton** *(aprox)* **of aggregates & 1000 Ton bitumen are required For 1 km road construction.**
- **20 lakh ton of material** *(aprox.)* **required for NHDP of 60 km road**
- **Bitumen Imports 49%**

**Existing resources will last only for next 15-20 years.**

*As per report of Federal Ministry of Environment, Nature conservation & Building, on "**Material Consumption patterns in India**-2016"*

**DELAYS due to Non availability of aggregates**
**Leads to HIGH increase in total cost of the project.**

**200 km of Road = 180 lakh litre of Diesel (gross)**
consumption in transportation

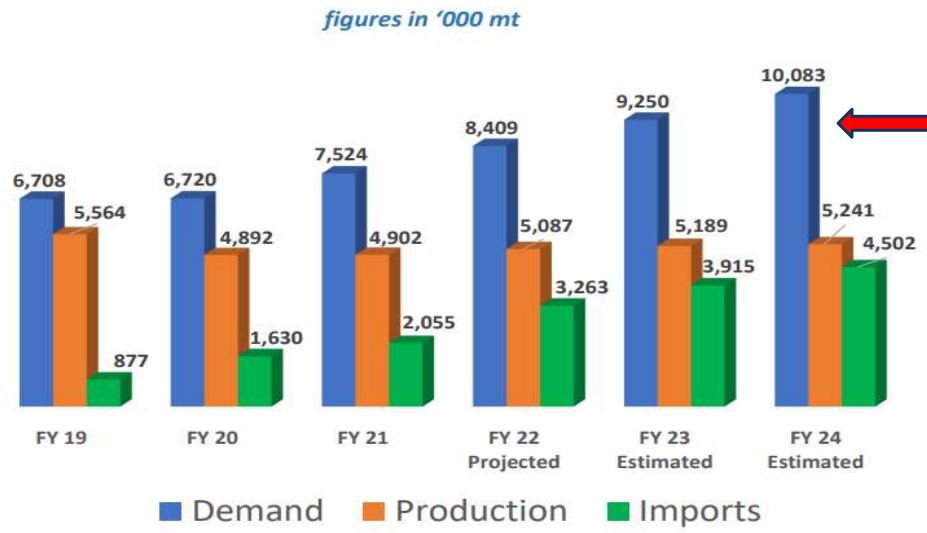



**Reduce Bitumen Imports with quick implementation alternative innovative technology**

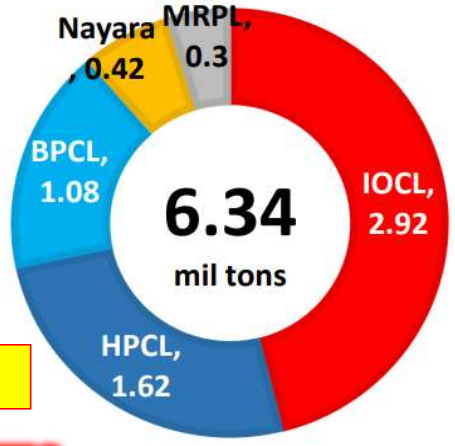
# CURRENT SCENARIO OF BITUMEN DEMAND-SUPPLY

**Most of the bitumen comes from heavy crude oil which has high carbon foot print**

**STAGNANT DOMESTIC PRODUCTION**




Increasing Supply Gap met by Imports




**MAX PRODUCTION CAPACITY**

*figures in '000 mt*

| Oil Company | Location | Capacity |
|---|---|---|
| IOC | Mathura | 750 |
| IOC | Panipat | 420 |
| IOC | Koyali | 500 |
| IOC | Haldia | 650 |
| IOC (CPCL) | Chennai | 500 |
| IOC | Barauni | 100 |
| HPCL | Mumbai | 680 |
| HPCL | Vizag | 440 |
| HPCL (HMEL) | Bhatinda | 500 |
| MRPL | Mangalore | 300 |
| BPCL | Mumbai | 680 |
| BPCL | Kochi | 400 |
| Nayara | Jamnagar | 420 |
| **Grand total** | | **6,340** |

ESTIMATED ANNUAL IMPORT COST: 0.25 LAKH CRORES

**NEED : BIO-BINDER/BIO-BITUMEN**

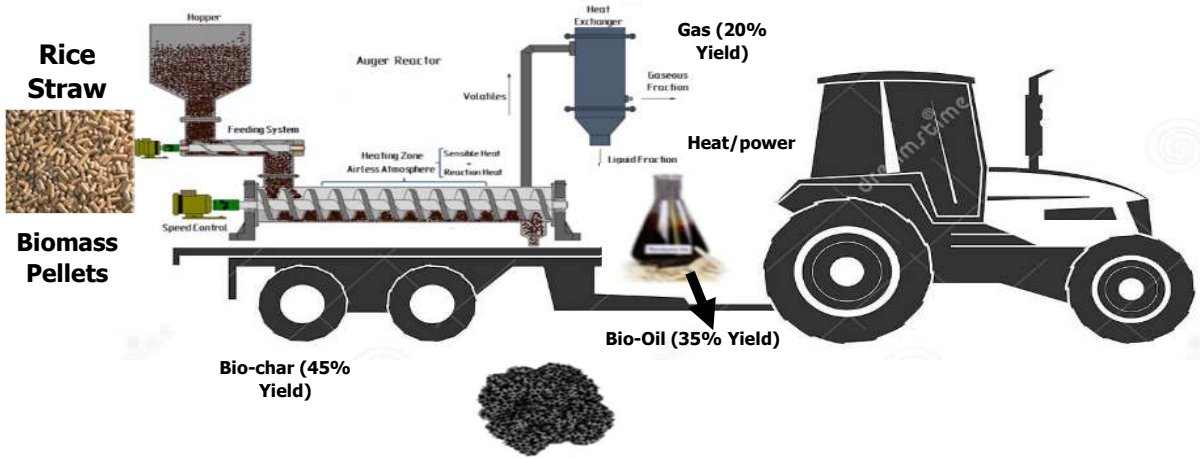
# Development of *Bio-binder* for Construction of ROADS

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



- chemical characteristics and composition of bio-binders
- Aging effect and rheological characterizatio n
- bond strength between the bio binders and aggregates
- mixing and compaction temperatures of the bio binders
- Performance evaluation of bio-binders
- Developing technical specifications.

# Production of Bio-binder




*Production of Bio-Oil from Rice Straw*

- 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 30 wt.% respectively.
- **Bio-oil was then processed by a series of chemical unit operations for production of bio-binder/bio-bitumen.**

# Different Bio-binders Produced & Evaluated

## Softening Point

Softening point of VG 40 (V) – 53.9 ° C
BASE (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 |

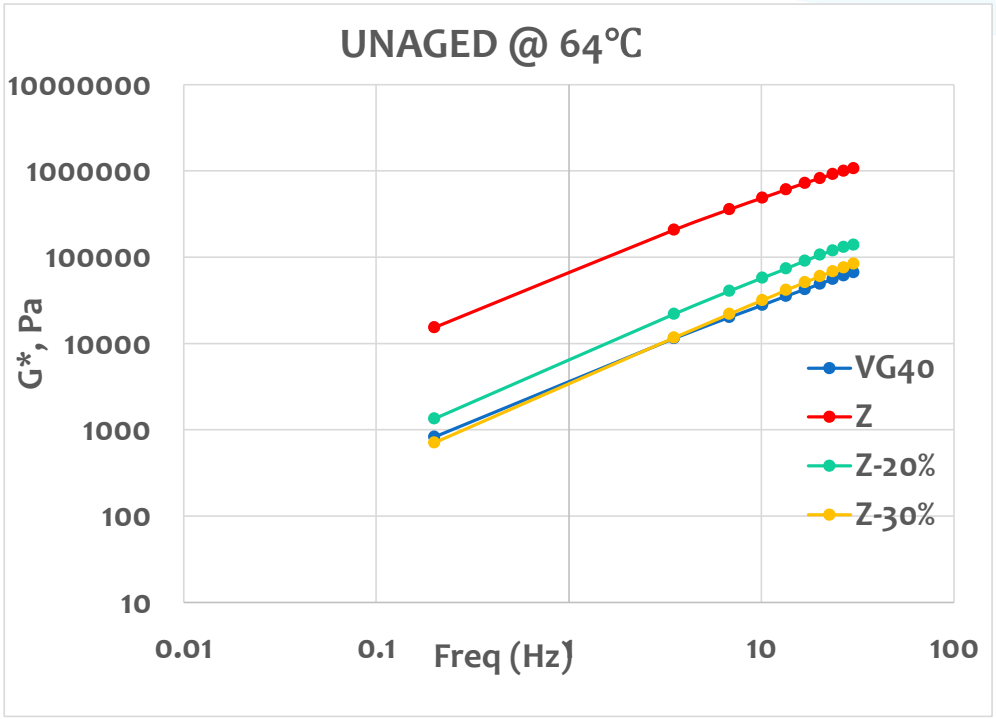
## Complex Modulus

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

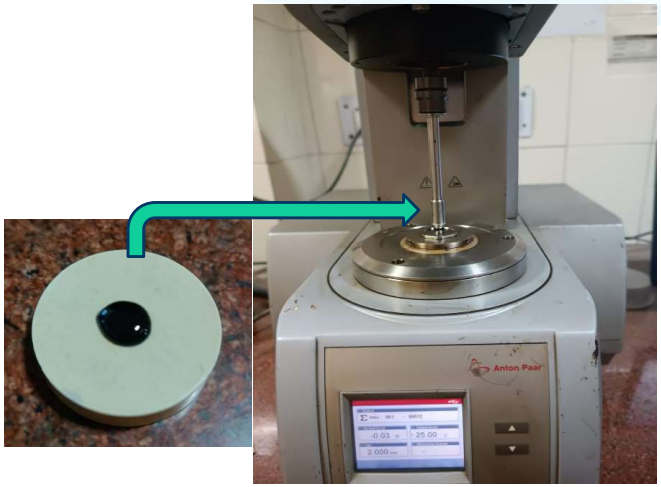
Rutting Parameter

| 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

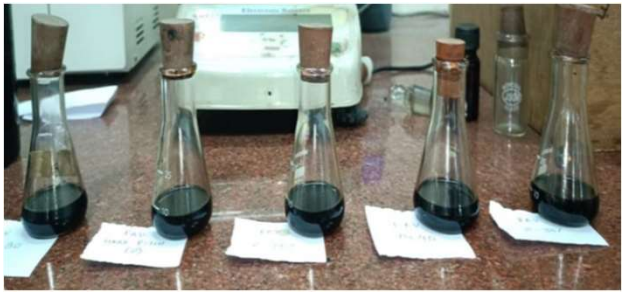



**Complex modulus using Dynamic shear Rheometer**



# Chemical Properties: SARA Analysis

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



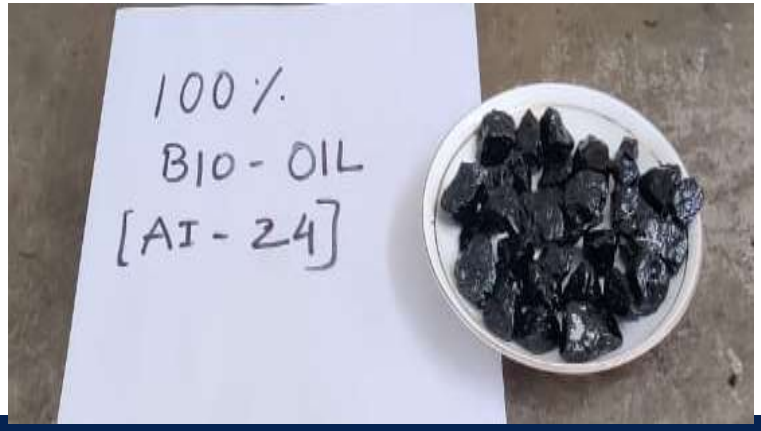
| Sample | Saturates,% | Aromatics, % | Resins,% | Asphaltenes, % |
|---|---|---|---|---|
| VG 40 | 15.93 | 31.36 | 44.34 | 8.37 |
| Bio oil | 0.00 | 0.00 | 85.46 | 14.54 |
| Base Material (Z) | 1.66 | 48.65 | 44.28 | 5.42 |

| Sample | Saturates % | Aromatics % | Resins % | Asphaltenes % |
|---|---|---|---|---|
| Base Material (Z)+ 25% Bio oil | 14.12 | 36.47 | 41.46 | 7.95 |

# Asphalt Mix Preparation

* **Aggregates mixed with bitumen & bio-bitumen**

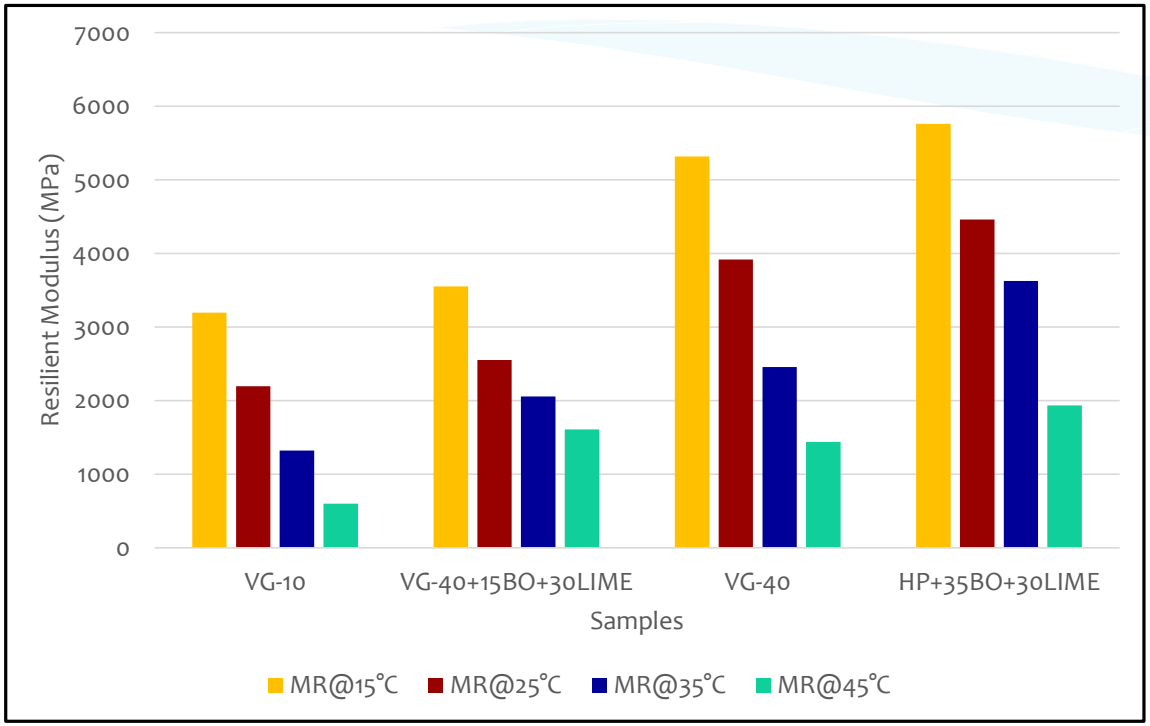
Aggregates coated with bio- bitumen


# Indirect Tensile Strength (ITS)

| Type of Mix | Indirect Tensile Strength (kPa) | | Tensile Strength Ratio (%) |
|---|---|---|---|
| | Unconditioned Specimens | Conditioned Specimens | |
| VG30 | 955 | 873 | 91.4 |
| VG40 | 1105 | 1002 | 90.7 |
| Z-30% | 1050 | 962 | 91.6 |


# Resilient Modulus




# Moisture Resistance: Stripping Test

Aggregates coated with biobinder
BEFORE BOILING TEST

Aggregates coated with biobinder
AFTER BOIILING TEST

*Stripping Test Conducted for different boiling periods ( 10 min, 30 min and 60 min)*

# Moisture Resistance: Stripping Test


BEFORE BOILING


AFTER BOIILING

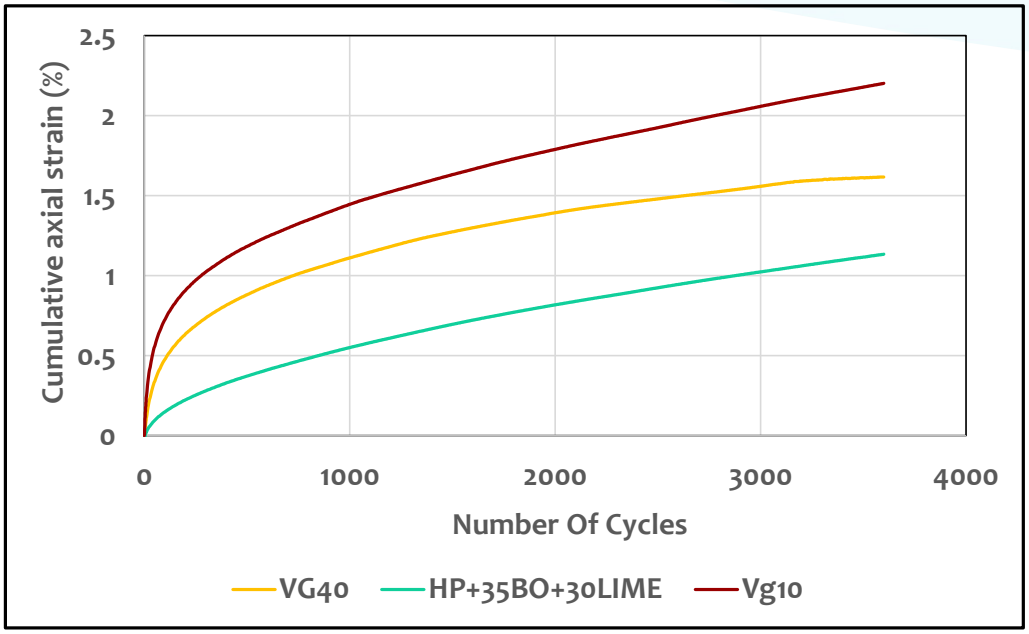
# Moisture Resistance: Stripping Test

VG-40 COATED AGGREGATES
AFTER BOIILING: 99.7% Coating

BIOBINDER COATED AGGREGATES
AFTER BOIILING: 99% Coating

*Coating % estimated by Image Analysis*

# Rutting Resistance: Dynamic Creep




**Loading Pulse** : Haversine
**Temperature** : 50° C
**Loading** :1s loading & 1s rest
**Duration** : 2 hours

# Performance Evaluation of 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, % 40 ° C |
|---|---|---|---|---|---|
| | Dry | Wet | | | |
| VG40 | 1105 | 1002 | 90.7 | 3350 | 1.80 |
| Biobinder | 1050 | 962 | 91.6 | 3400 | 1.79 |

# SUMMARY

- Higher ***resilient modulus*** of bituminous mix prepared with bio-binder mix at all test temperature compared to conventional bituminous mix.
- Rut resistance of bio-binder mix was better than that of VG40 mix.
- ***TSR*** of considered mixes was greater than the 80%.
- After ***Stripping test***, binder coating % estimated using Image Analysis. (>99% observed)
- The production of bitumen, the binder in asphalt, generates more than 30 megatons of CO2 per year. By reverse engineering the classical bitumen components and replacing them with natural resources, one of the largest sources of CO2 turns into one of the largest CO2 sinks.

# Discussions with MoRTH Officials

Office Of Nitin Gadkari
@OfficeOfNG

Teams from CSIR-CRRI and CSIR-IIP presented the outcome of their research on road construction with a bio-derived bitumen binder to Union Minister Shri @nitin_gadkari ji in Delhi today.

10:06 PM · 31/10/22 · Twitter for iPhone

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Office Of Nitin Gadkari
@OfficeOfNG

'Bitumen of quality matching that of petroleum-based bitumen binder can now be produced from rice straw'

Successful deployment of this can save a quarter lakh crores worth of bitumen imports for the nation.

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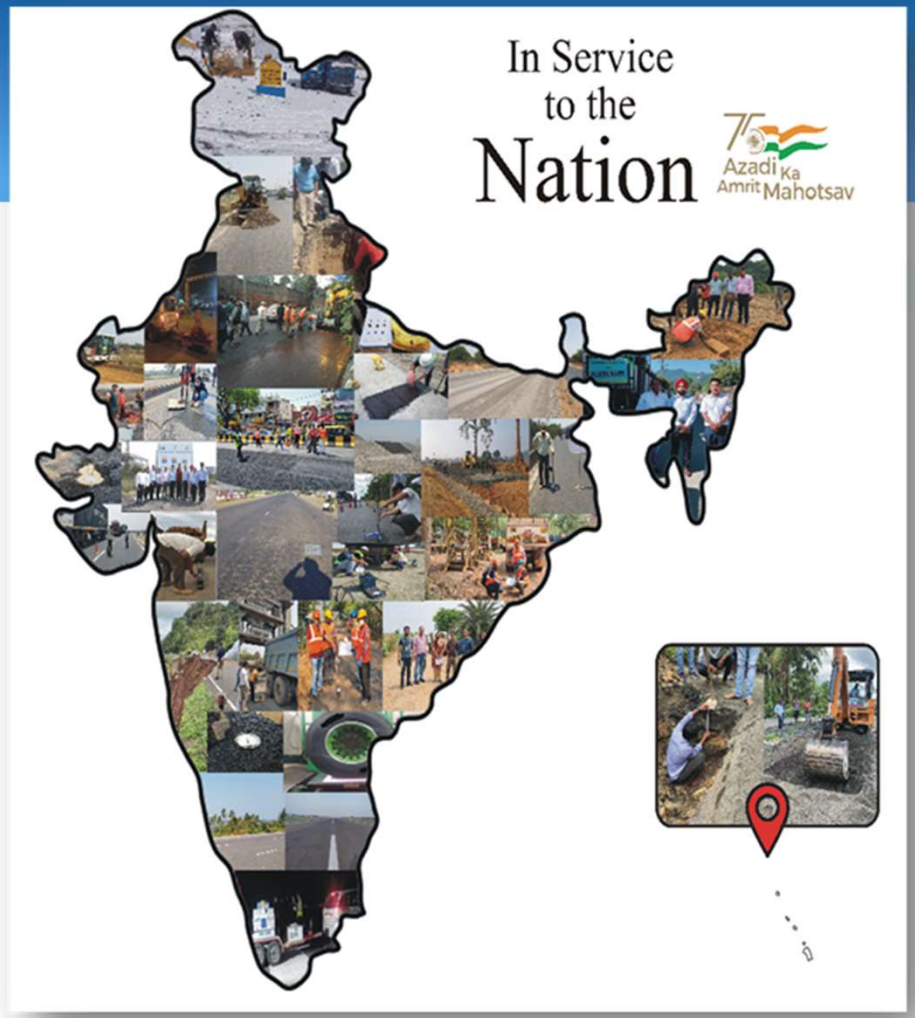
In Service
to the
Nation
Azadi Ka Amrit Mahotsav


Build Sustainably

# Thank you