6th Webinar on Research & Development Needs of Autonomous Vehicle Technologies in India – Its Practicality in India

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New Edge Technologies in Pavement Application

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Broad Outline

1. **Pavement Design**
2. **Life Cycle Cost Analysis with enhanced Life**
3. **Innovations – Design Optimization**
4. **Innovations – Bituminous / Concrete Mixtures**
5. **Innovations - Construction Techniques**
6. **Innovations – Accelerated Rehabilitation**

The stakeholders/users are demanding safer, longer-lasting & sustainable infrastructure. The overarching goal should be savings in life cycle cost, not initial cost. Saving now and paying later is plain simple irresponsible act.

Upgradation in Pavement Technologies

2001- Mechanistic Empirical Design Approach incorporating Material Properties

2010- Use of Stabilized Pavements

2013- Use of Alternative Materials

2014- Use of Falling Weight Deflectometer

2014- Use of Foam Bitumen Technology

2015- Use of RAP

2019- Expansion in the usage of Geosynthetics

2019- Starting Construction of Long Life / Perpetual Pavement

2022- Started Construction of High Dosage RAP in Flexible Pavement, Geosynthetic Reinforced Flexible Pavement & Bonded Rigid Pavement

Types of Pavement System

Flexible Pavement (Bituminous)

- High RAP Dosage
- Geosynthetic Reinforced Pavement
- Perpetual Flexible Pavement
- Conventional Flexible
- Semi Rigid Type (considering cement treated base / sub-base)
- Foam Bitumen Treated RAP

Rigid Pavement (Concrete)

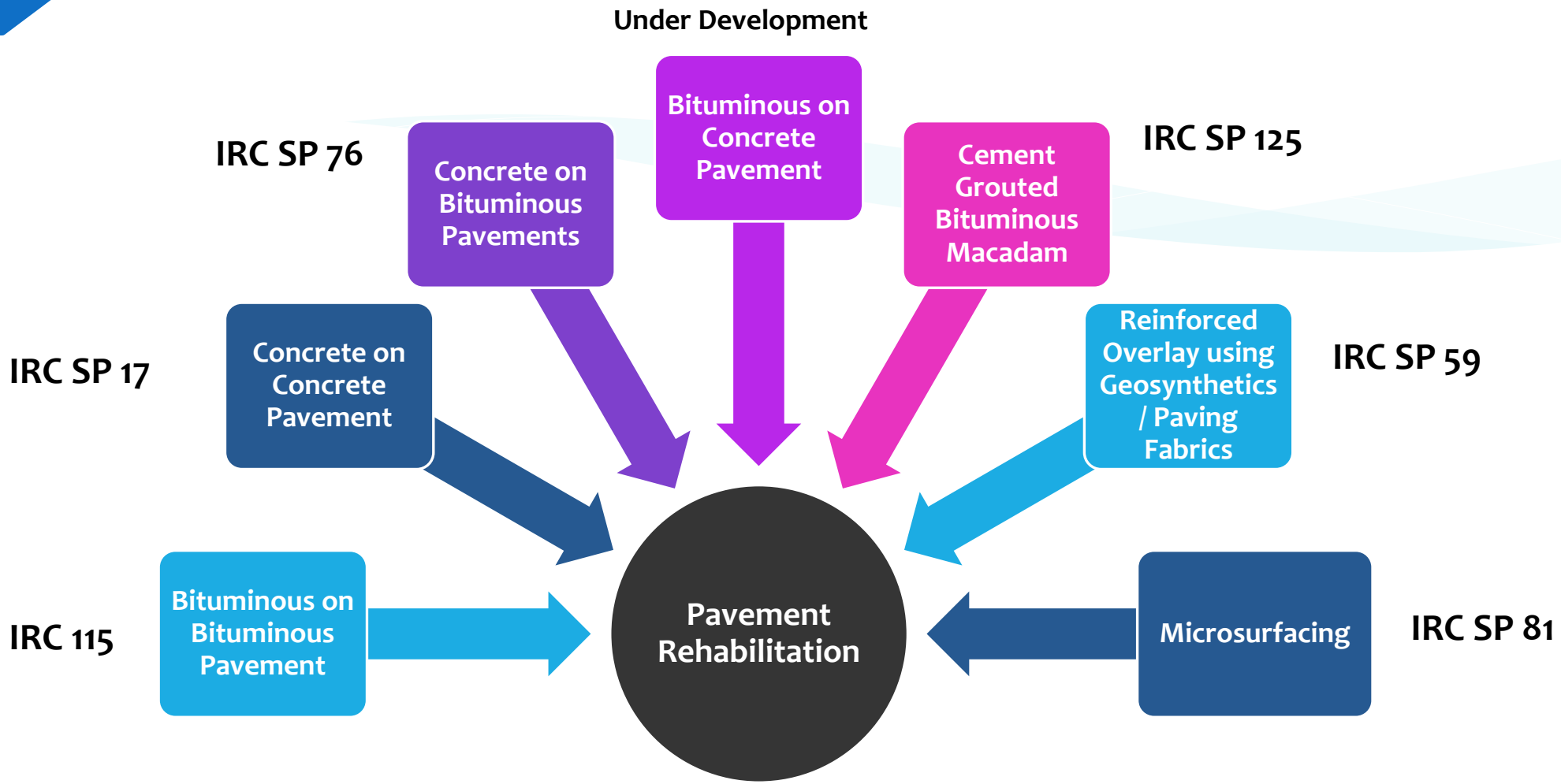
- Bonded Rigid
- Short Panelled Concrete Pavement
- Precast Prestressed Concrete Pavement
- Two Lift Concrete Pavement
- Conventional Rigid

Composite Pavement (Combination of Rigid & Flexible)

- Rigid over Flexible Pavement
- Flexible over Rigid Pavement

Latest Practices Under Consideration

Endeavor in Pavement Sustainability



Factors Affecting Pavement Performance

Important Parameters for Flexible pavement Structure:

1. **Axle Loading- Vehicle Damage Factor**

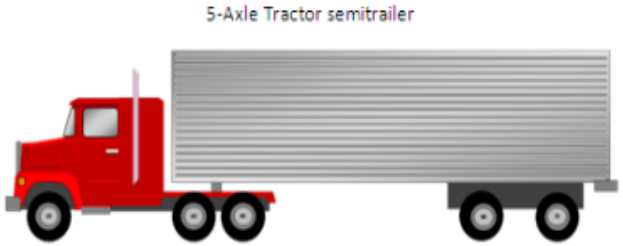
January 2024

Vehicle Type	Commodity	1st axle	2nd Axle	3rd Axle	4th Axle	5th Axle	Total Weight
MAV(1.22.22)	Sand	12520	20920	19980	21200	21660	**96280 kg**

VDF = (12520/6600)^4 + ((20920+19980)/15100)^4 + ((21200+21660)/15100)^4

= **131.68**

Is our Flexible Pavement capable of taking these high VDFs?



2. **Environmental Condition- Ambient Temperature**

Rising more than 45C

Allowable (Legal) Load of the 5 Axle Truck = **7 + 21 + 21 = 49 tons**

VDF at legal limit= (7/6.6)^4+(21/15.1)^4+(21/15.1)^4

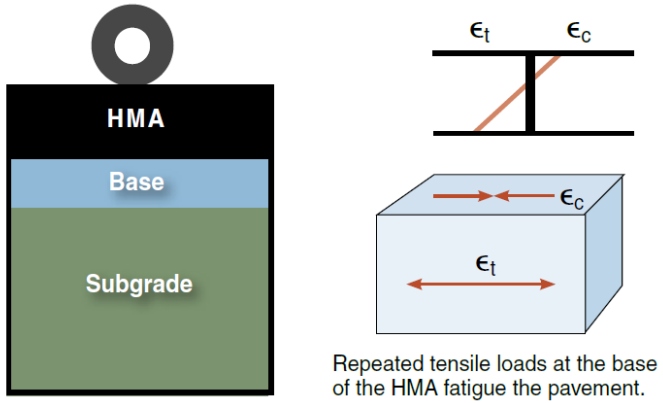
= **8.77**

Perpetual Pavement- Design Philosophy

What is a Perpetual Pavement:

- ✓ Should have design life of 50 years
- ✓ Should be easily Recyclable, less noisy, smooth riding
- ✓ Doesn't require Major Structural Rehabilitation
- ✓ Should sustain unlimited Traffic repetitions

The design concept of perpetual pavement is based on the FHWA guidelines



Repeated tensile loads at the base of the HMA fatigue the pavement.

Type of Layer	Endurance Limit (microns)	
	IRC 37-2018	FHWA
Bituminous Layer (Fatigue)	80	70
Granular Layer (Rutting)	200	200

Top Layer- Designed for Abrasion resistance & vehicle safety. It is of high modified mix; gap graded mix; SMA.

Third Layer- To resist surface-initiated distress (top-down cracking), rutting etc.)

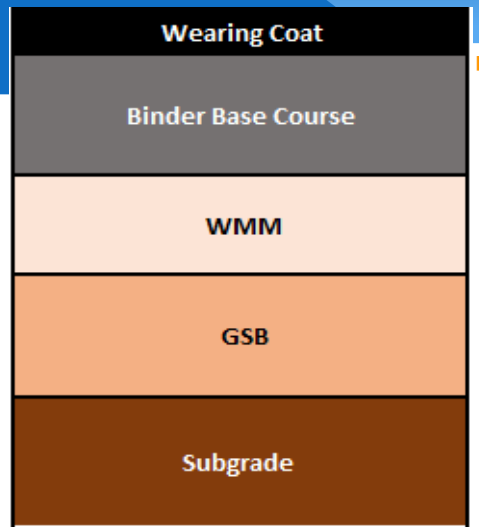
Second Layer- Increase Bending Stiffness (by use of stiffer conventional asphalt & higher RAP)

Bottom Most Layer (also called Rich Bottom Layer)- To resist damage under tensile strain (bottom-up cracking)

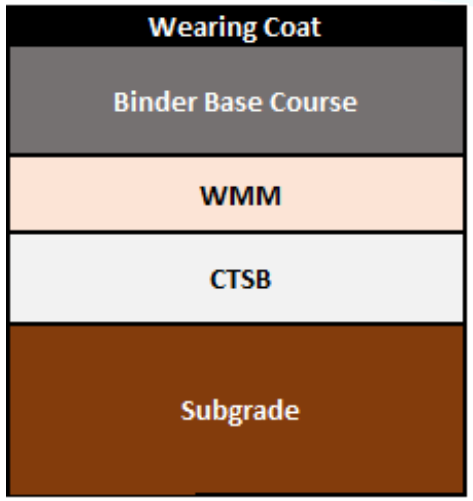
Granular Layer- To serve as platform for asphalt layers

Subgrade- Well compacted to desired properties as it serves as foundation for the pavement.

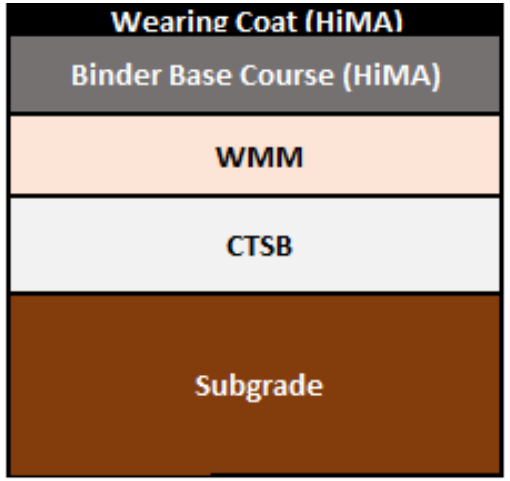
Perpetual Pavement Examples (India)



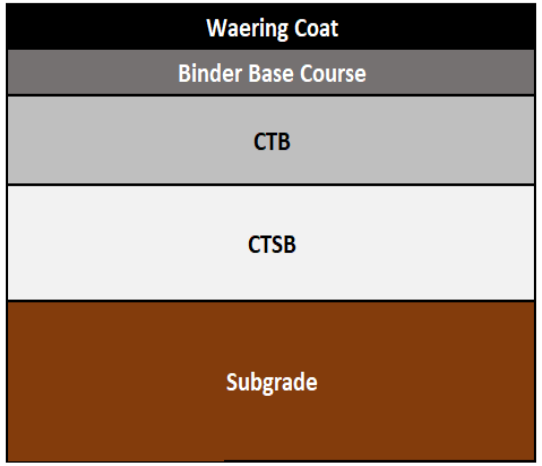
- Thick Bituminous Pavement with Granular Base And Subbase



- Thick bituminous pavement with Cemented granular sub-base layer



- High Modulus Binder Mix (Resilient Modulus of 5500 MPa) in Pavement



- Thin bituminous pavement with Cemented granular base & sub-base layer

Pavement Alternatives considered for LCCA

Option 1	Flexible Pavement- Conventional Type	
Layer No	Layer Type	Thickness (mm)
1	SMA	50
2	DBM	250
3	WMM	150
4	GSB	200

Option 2	Flexible Pavement- Semi Rigid (CTSB)	
Layer No	Layer Type	Thickness (mm)
1	SMA	50
2	DBM	200
3	WMM	150
4	CTSB	250

Option 3	Flexible Pavement- Semi Rigid (CTB)	
Layer No	Layer Type	Thickness (mm)
1	SMA	50
2	DBM	140
3	Aggregate Interlayer	100
4	CTB	150
5	GSB	200

Option 4	Rigid Pavement	
Layer No	Layer Type	Thickness (mm)
1	PQC	330
2	DLC	150
3	GSB	150

Option 5	Bonded Rigid Pavement	
Layer No	Layer Type	Thickness (mm)
1	PQC	270
2	Bonded DLC	150
3	GSB	200

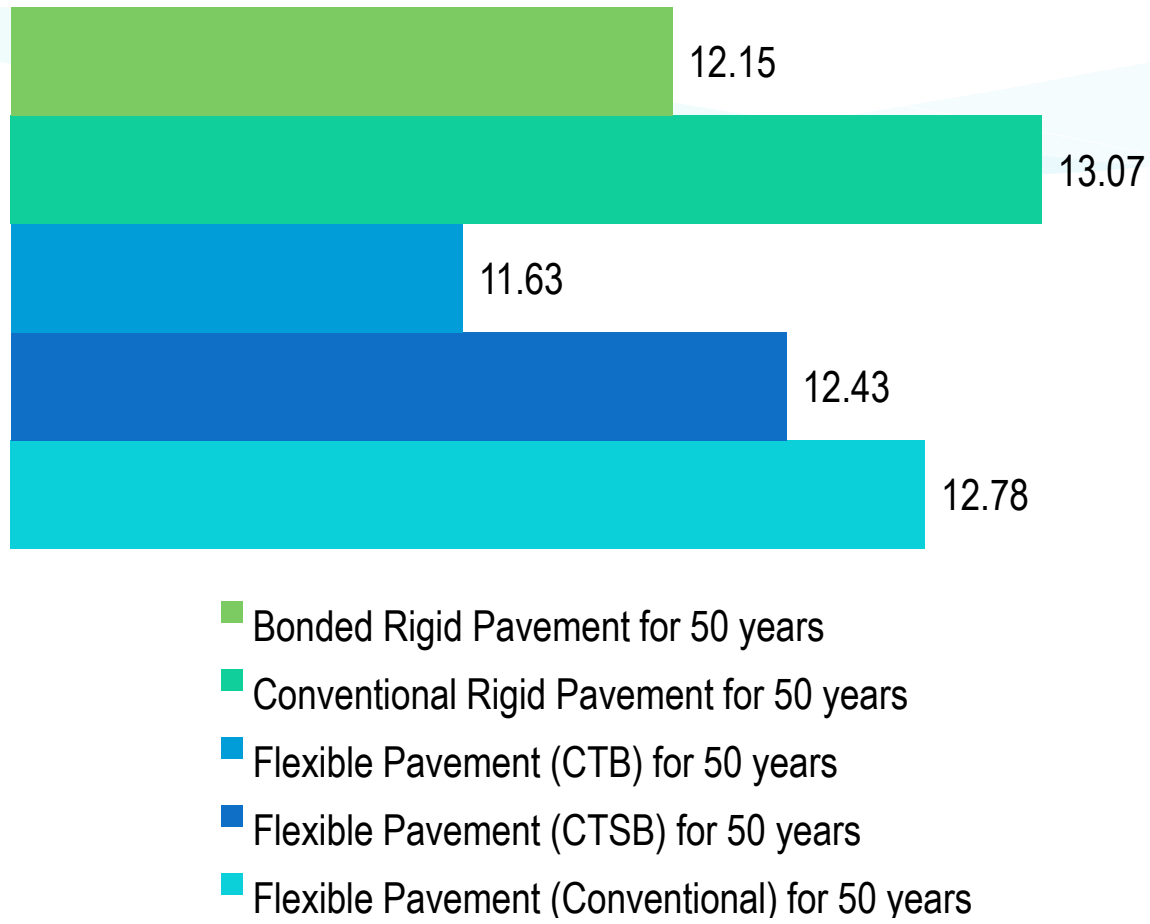
Maintenance Regime Adopted		
Year	Flexible	Rigid
10	Functional Overlay	Strengthening
15	Strengthening	-
20	Functional Overlay	Strengthening
25	Structural Overlay	-
30	Functional Overlay	Partial Reconstruction
35	Strengthening	-
40	Functional Overlay	Strengthening
45	Functional Overlay	-

* Routine Maintenance is adopted every year.

Life Cycle Cost Analysis

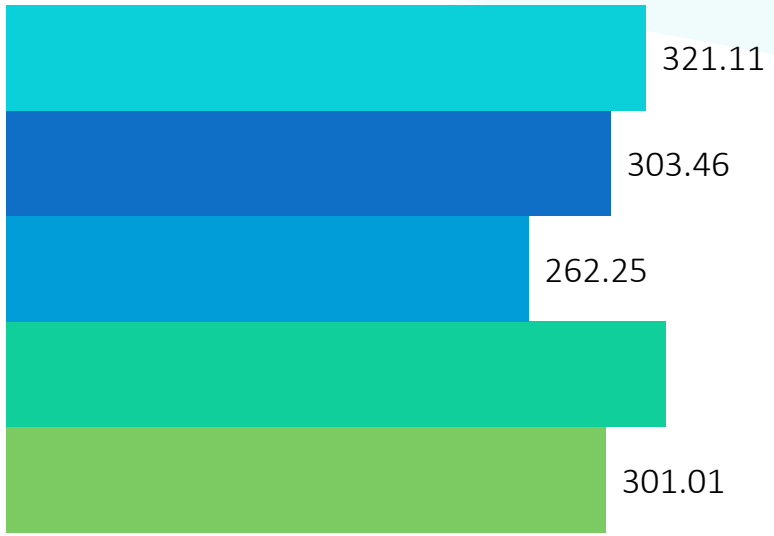
For a 8 Lane Expressway, for 50 years of design life considering 18.75m each side carriageway width;

The per km LCCA with different pavement alternatives is shown in graph.

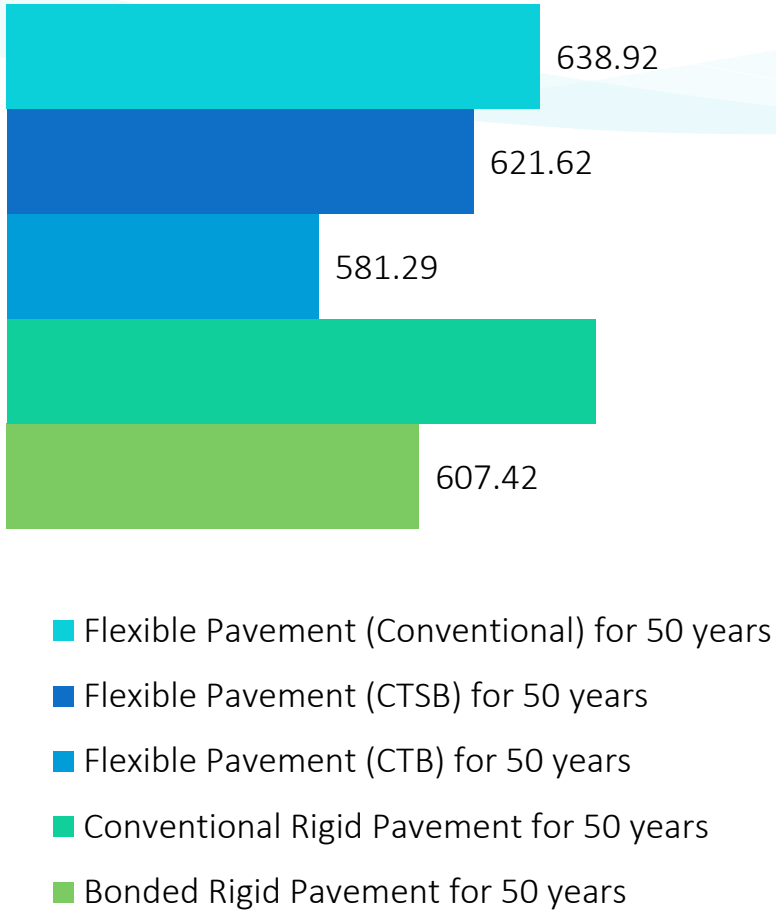


Life Cycle Cost Analysis Comparison

Comparison of Intial Construction Cost in Rs crores



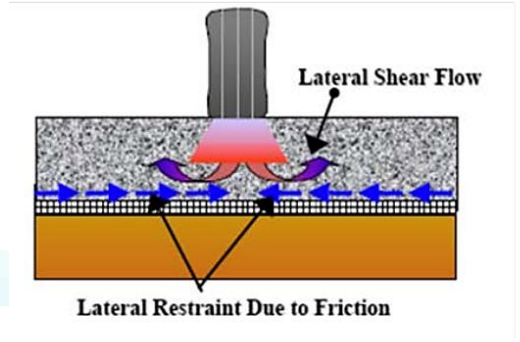
Comparison of Life Cycle Total Cost in Rs crores

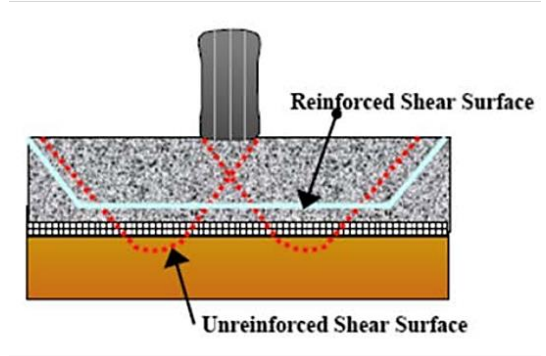


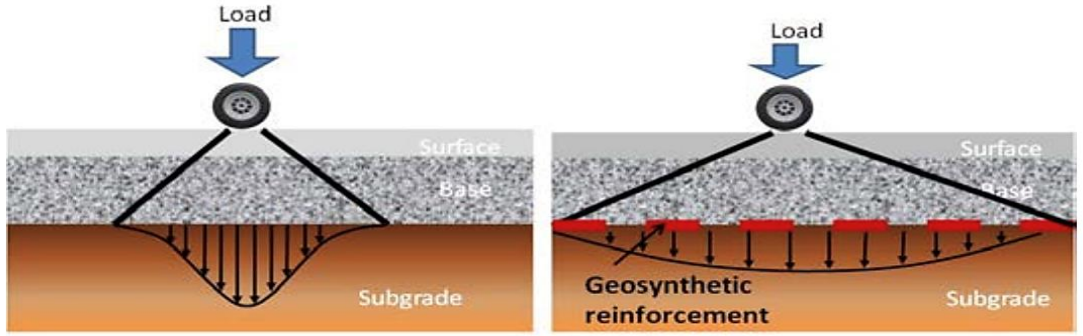
Snapshots of Constructed Perpetual Pavement

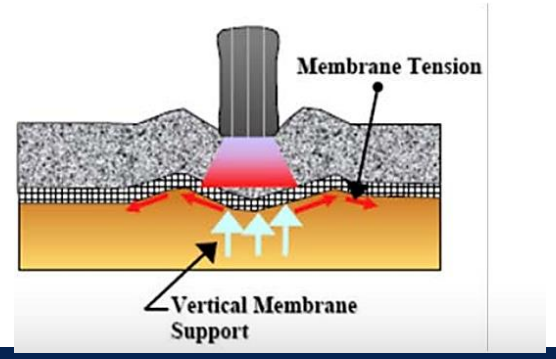
Geosynthetic Reinforced Flexible Pavement

- The design concept of geosynthetic reinforced pavement is same as that of Conventional Flexible Pavement
- Designed as per IRC SP 59-2019 in line with
- IRC 37-2018.
- Design Concept:
  - Lateral Restraint,
  - Improved Bearing Capacity
- Geosynthetic- Geocell or Geogrid









Construction Procedure of Geosynthetic Reinforced WMM Layer


Preparation of GSB for Placement of Geogrid


Placement of Biaxial Geogrid Layer over Prepared GSB


Nailing of J hook pins to keep the geogrid in position


Laying & Compaction of WMM Layer


Compacted WMM Layer

Quality Assurance Test Plan during Construction of Geogrid Reinforced Pavement

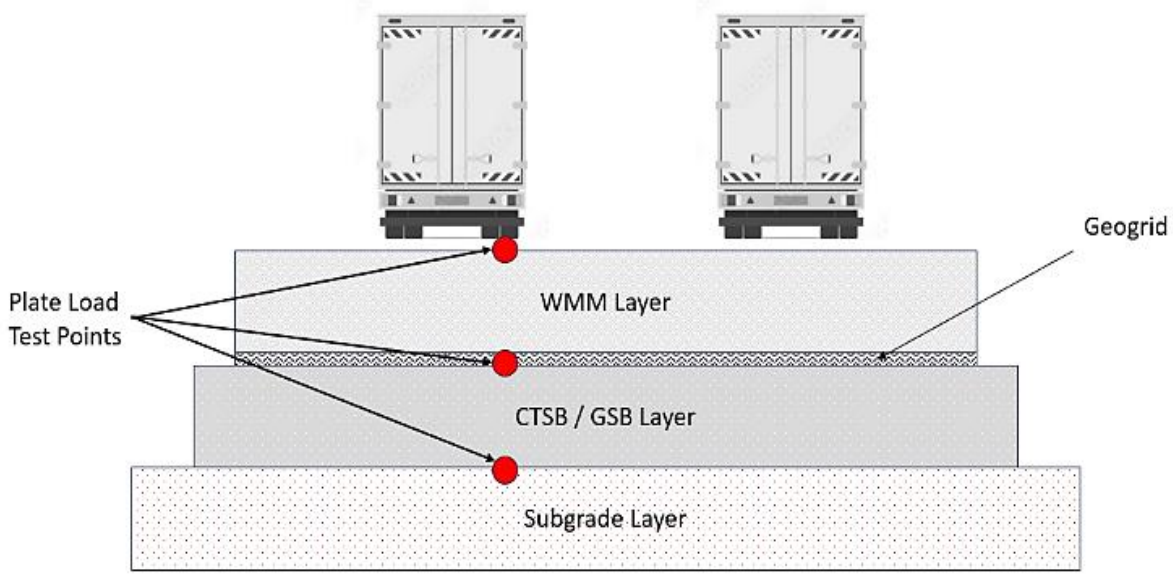


Plate Load Testing Location for Single Layer Geogrid Reinforced Pavement

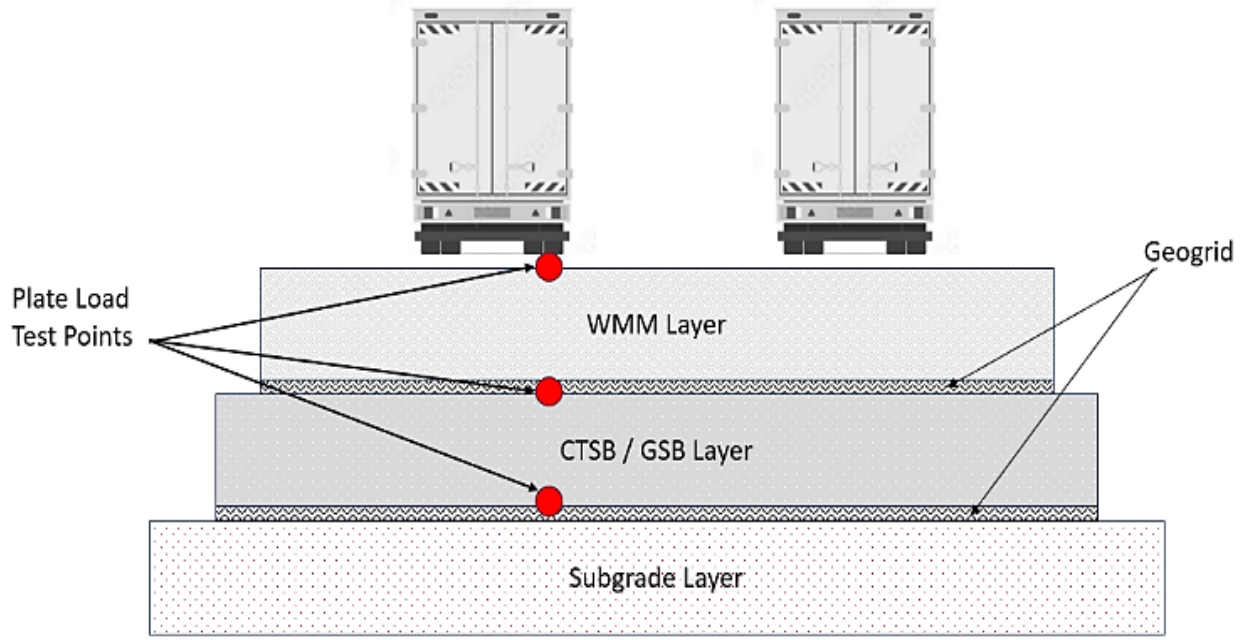
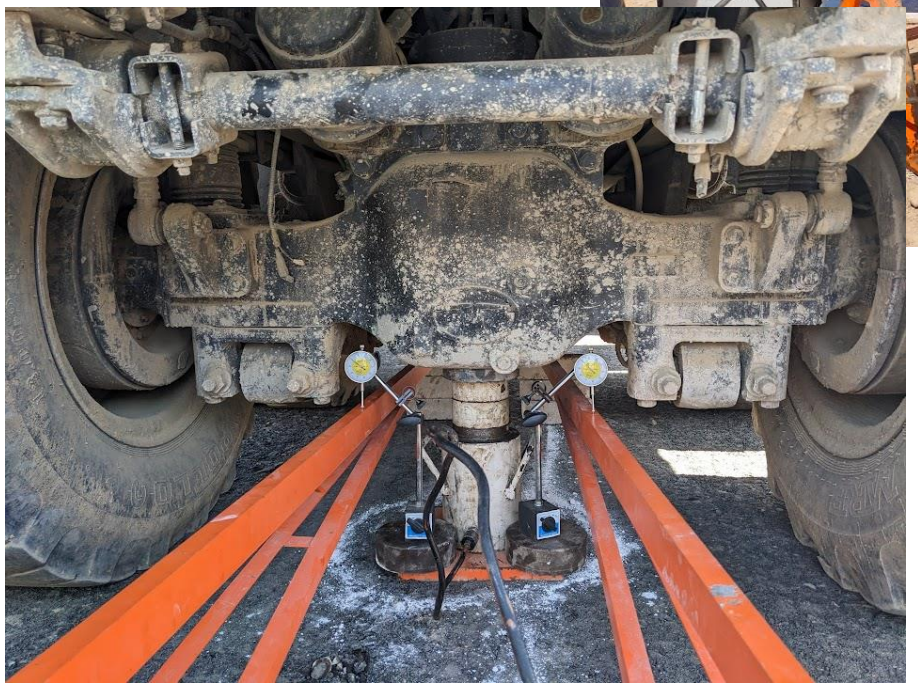
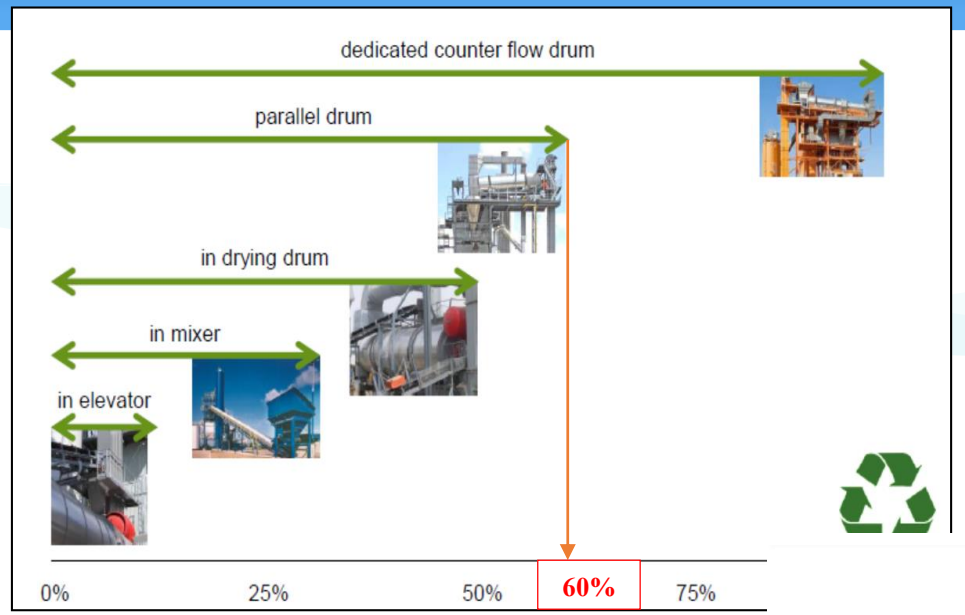


Plate Load Testing Location for Double Layer Geogrid Reinforced Pavement

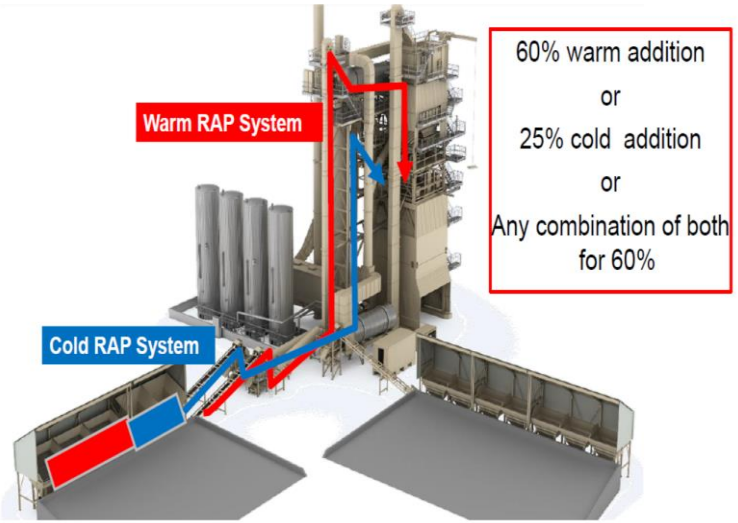


Usage of High RAP Dosage by Hot in Plant Recycling

- ✓ Now a days the HMP plant produce bituminous mix with fresh aggregates or mix of fresh and RAPM.
- ✓ In India, the bituminous mixes are produced with the ratio of 70:30 :: Fresh Aggregate : RAPM.
- ✓ High RAP is still not regular engineering in India yet, due to the special bituminous batching plant requirements.
- ✓ Based on the intended dosage and type of recycling, different plant set-ups are available.



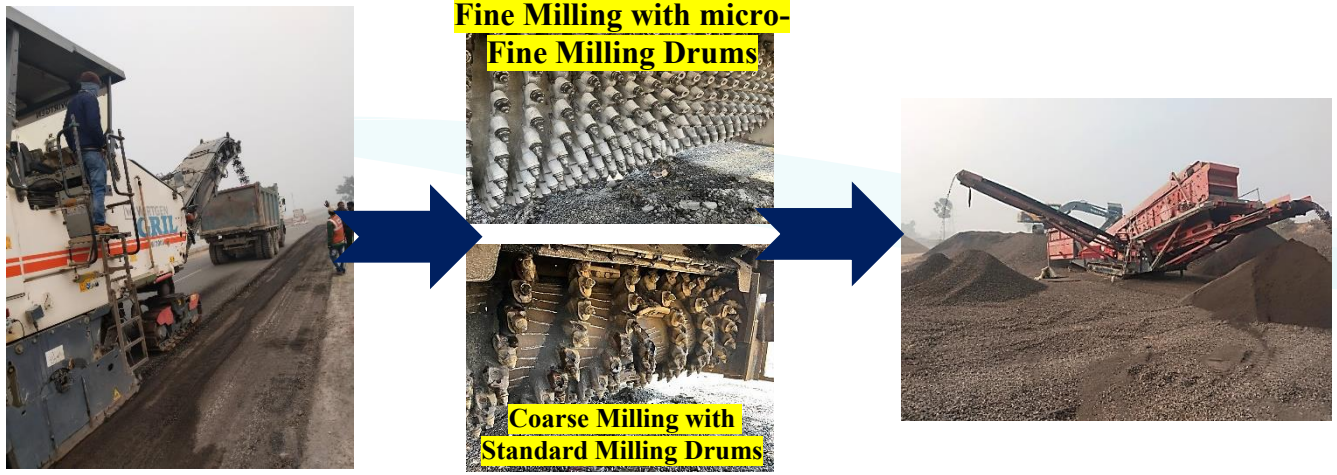
Layouts of HMP Various Dosages of RAP Recycling



Schematic of RAP Addition System in HMP

Usage of High RAP Dosage by Hot in Plant Recycling

- ✓ Two Step Milling was adopted
- ✓ The first milling was done on top 50mm Bituminous Concrete.
- ✓ The Other Milling was done on bottom 100mm of Bituminous Base course.
- ✓ The milling from pavement layers were further screened into further sizes and stored in bins.



Steps for a **Quality RAP** Product

1. Obtain the RAP
2. Crush / screen the RAP
3. Stockpile the RAP
4. Test the RAP as Stockpiled
5. Use the RAP
6. Test the RAP as Consumed

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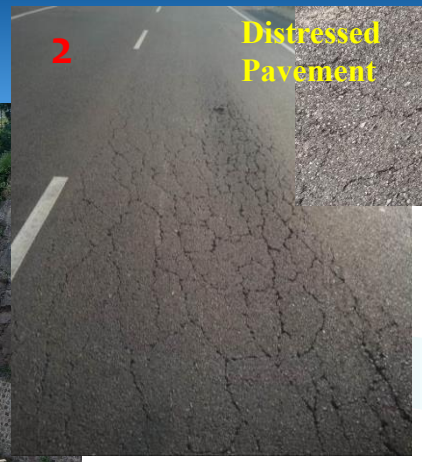
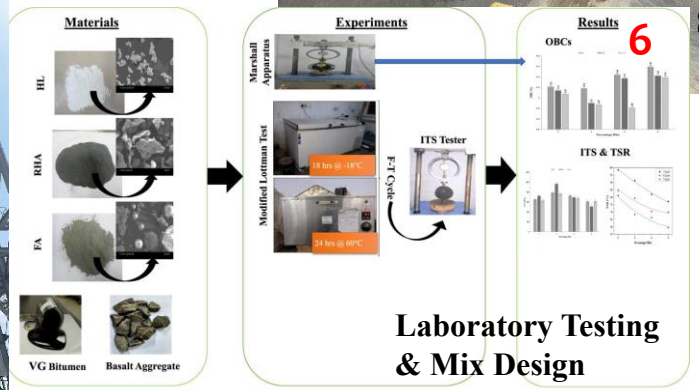
- ✓ *RAP is heated in different barrel.*
- ✓ *Heated RAP is added with Heated Virgin Aggregate into the Pug Mill.*
- ✓ *Virgin Binder and Rejuvenators are added.*
- ✓ *Mixing Time is higher in Pugmill to provide homogenous mix.*

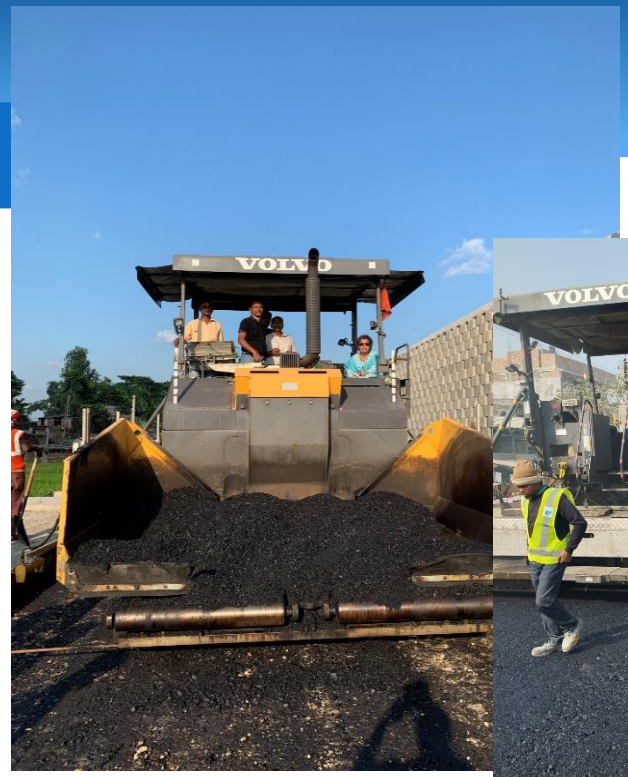
Parallel Drum is used for High RAP mixes

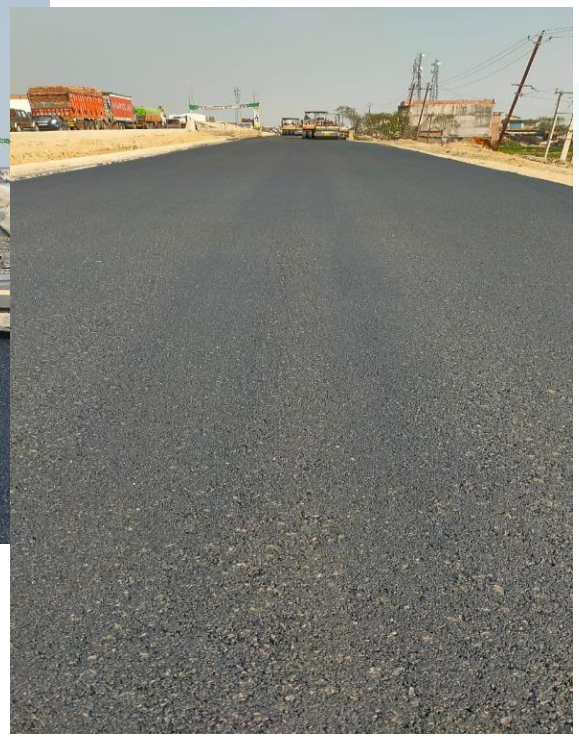
Flow Chart for RAP Recycling

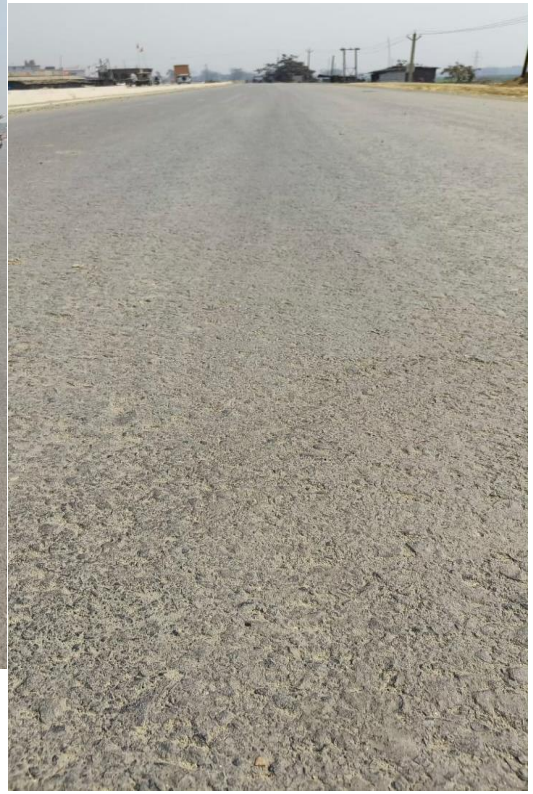




Usage of High RAP Dosage by Hot in Plant Recycling







Snapshots of DBM Laid with 60% RAP (Hot in Plant)

Cost Comparison for Conventional & High RAP Mix per ton

S. No.	Particular	DBM 2 Mix without RAP	DBM 2 Mix with 60% RAP	Remark
1	Plant Running Cost, INR per ton	₹ 400.00	₹ 750.00	Expense
2	Aggregate Requirement, tonnes per of ton mix	0.96	0.4	-
	Rate of Aggregate, INR per ton of mix @ 1,200 INR	₹ 1,152.00	₹ 480.00	Saving
3	Fresh Bitumen Requirement, tonnes per ton of mix	0.04	0.022	-
	Rate of Bitumen, INR per ton of mix @ 55,000 INR	₹ 2,200.00	₹ 1,210.00	Saving
4	Rejuvenator Dose, kg per ton of RAP Bitumen	-	1.6	-
	Rejuvenator Cost, INR per ton of mix @ 300 INR	₹ 0.00	₹ 480.00	Expense
5	Overall Cost per ton of mix production, INR	₹ 3,752.00	₹ 2,920.00	INR 832 Saving
6	Extra Cost for Hot Mix Plant Upgradation	-	₹ 5,00,00,000.00	Investment

**To makeup the investment cost of approx. INR 5 Crores (for HMP upgradation) it is required to produce 70,000 tons of mix (including routine maintenance of plant). It is required to rehabilitate about 35kms of 2-lane with approx. 80mm thick DBM (subjected to high aggregate cost only; if the aggregate cost is less than the savings would be too less).*

The Advantages of the Parallel Flow Hot Mix Plant:

i. The bitumen film will not be overheated and damaged
ii. Recycling temperature by the dryer outlet at around 130°C
iii. Use of screen not affected
iv. Good to combine with low temperature mixes

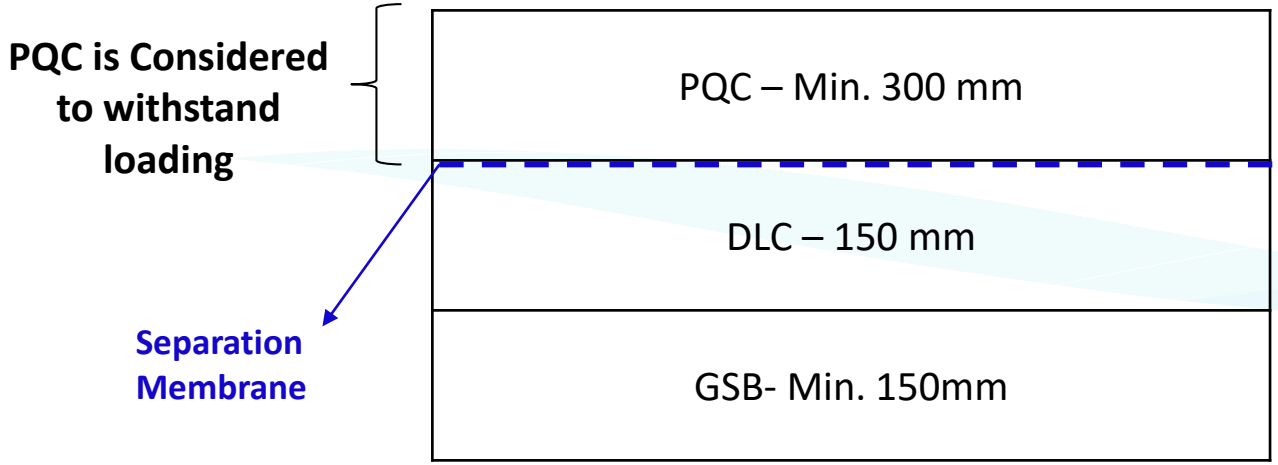
Limiting Factors:

i. Parallel flow dryer has some temperature limitations
ii. Superheating of aggregates is required, which is environment unfriendly

New Edge Rigid Pavement

- Bonded Rigid Pavement
- Two lift concrete pavement
- Short Panel Concrete Pavement
- Concrete Overlay Over Concrete Pavement
- Pre-stressed Precast Concrete Pavement
- Composite Pavement

Conventional Rigid Pavement (Jointed Plain Concrete Pavement)

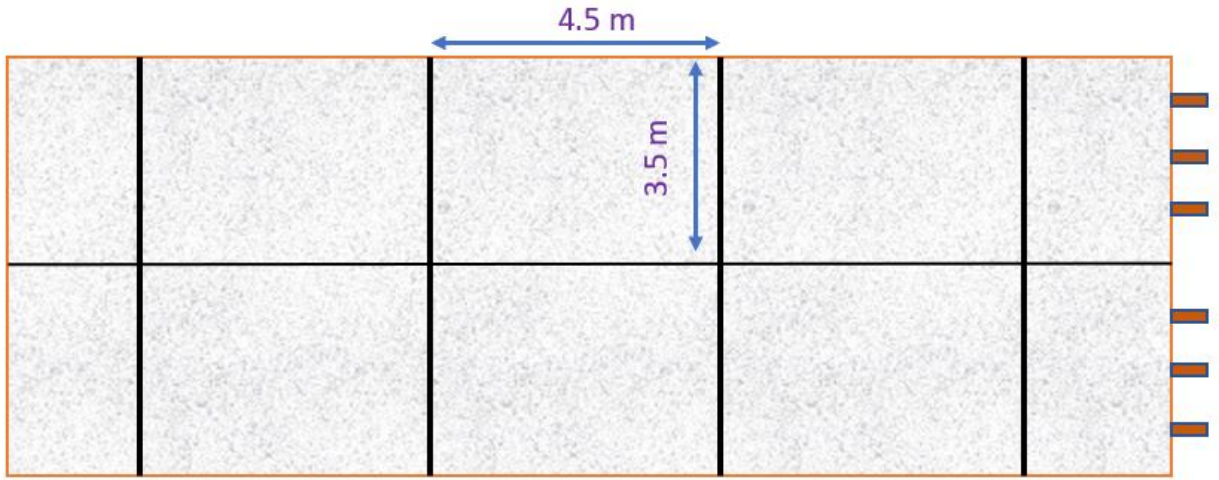


The conventional 300mm PQC (approx.)

Separation Membrane- 150-micron PVC Sheet

Load Transfer through Dowel Bars- Generally 32mm dia., 300mm spacing & 500mm length)

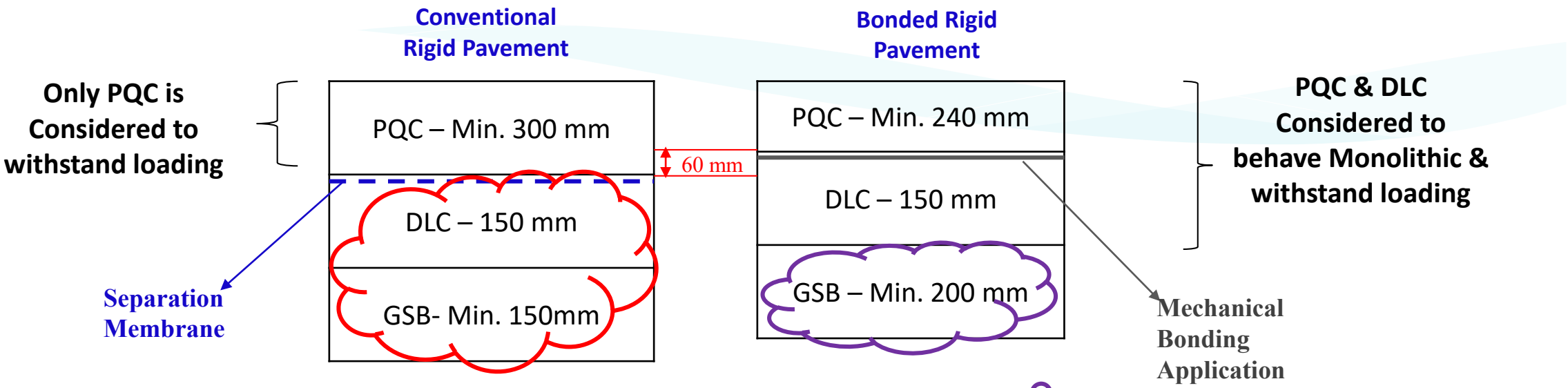
Tie Bars (at Longitudinal Joint)- Generally 12mm dia. deformed, 500 mm spacing & 640 mm length)



Plan view of JPCP

Bonded Rigid Pavement

Conventional v/s Bonded Rigid Pavement- Design Principle



The conventional 300mm PQC (approx.)

is considered equivalent to

combined (240mm PQC+150mmDLC) (approx.)

DLC, GSB & Subgrade Considered as Foundation

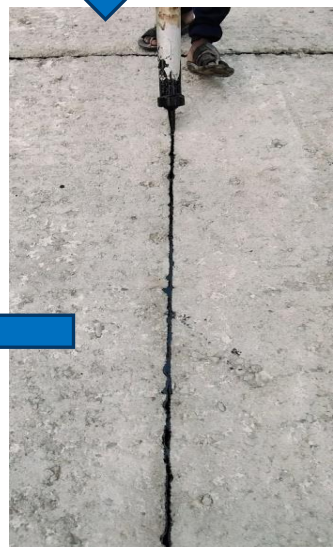
GSB & Subgrade Considered as Foundation

Methodology for Bonded Rigid Pavement


Prepared GSB Bed


Laying of DLC

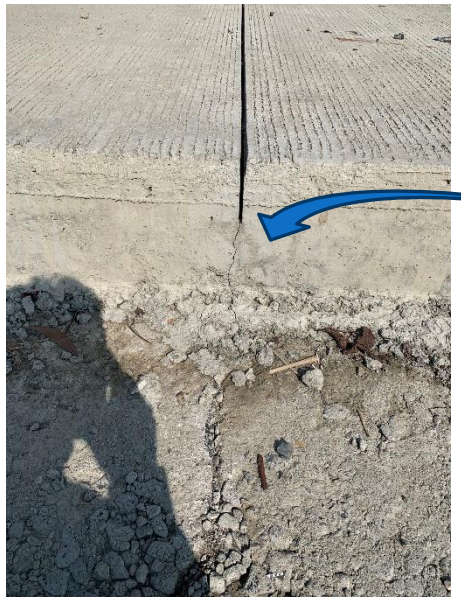

Texturing of DLC
(Mechanical Bonding)


Joint Cutting &
Sealing in DLC


Laying of PQC


Mapping of Joints in DLC & PQC

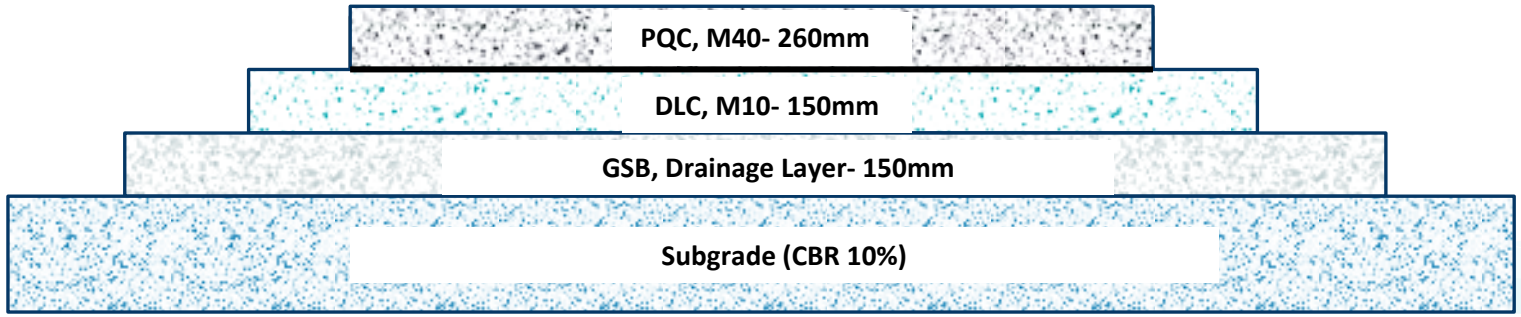

Core of
Bonded
DLC &
PQC



Snapshots of Constructed Bonded Rigid Pavement

Short Panelled Concrete Pavement

1m X 1m Joint Cutting in Entire PQC



A Typical Short Paneled Concrete Pavement System

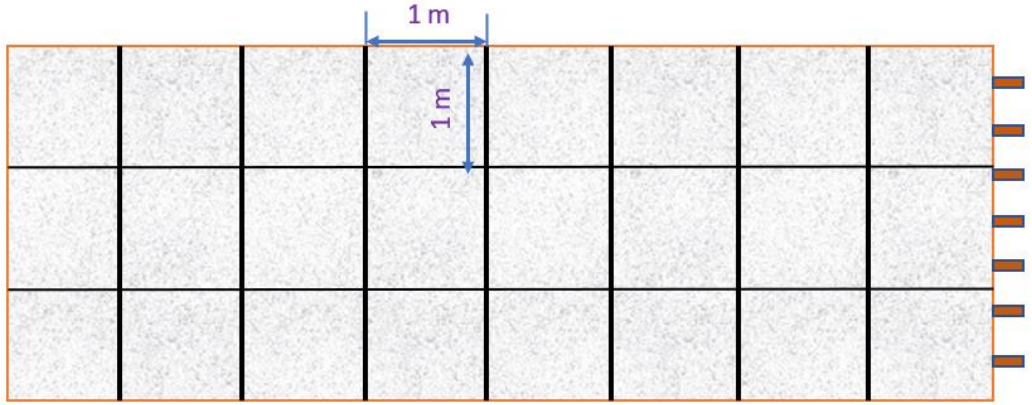
Separation Membrane- 150-micron polyethene sheet

Dowel Bars (Construction Joint Location Only) (32mm dia., 300mm spacing & 500mm length)

Tie Bars (Construction Joint Location only)- Approx. 12mm dia. deformed, 800mm spacing & 560mm length)

Advantages:

- No need for Dowel or Tie Bars (only required at expansion / construction joints.
- Easy Maintenance
- Less Thickness



Plan View of Short Paneled Concrete Pavement (SPCP)

Thin Concrete Overlays (over Flexible & Rigid Pavement)

- Thin unbonded overlay (placed over **Flexible (IRC SP 76)** or **Concrete Pavement (IRC SP 17)**)
  - Conventional: t ≥ 200 mm
  - Thin (recent):
    - Thickness – 125 to 175 mm
    - Jointing – 1.5 by 2 m
- Thin bonded overlays of AC pavements
  - Thickness – 125 to 175 mm.
  - Jointing – 1.8 by 1.8 m

Thin Concrete Overlays (of Asphalt & Concrete Pavement)

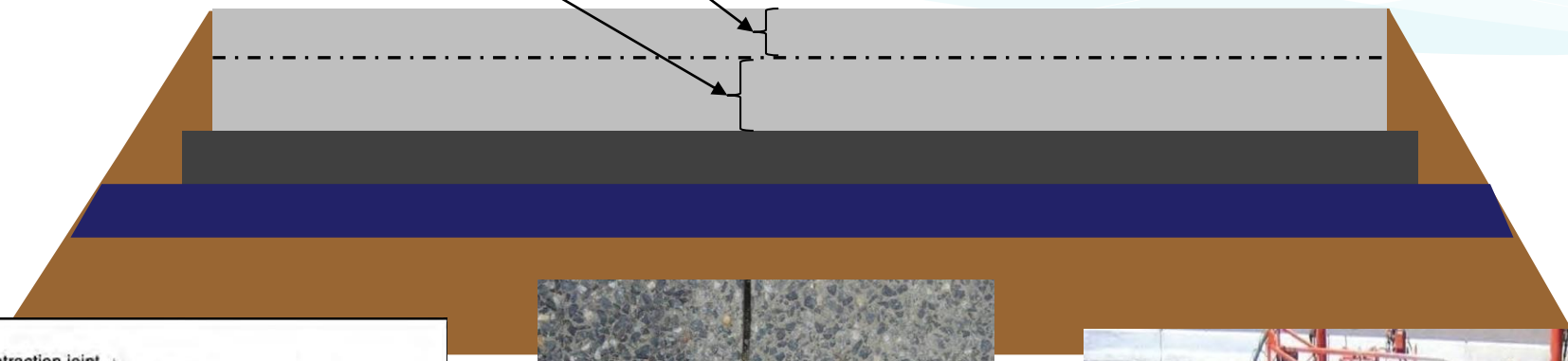
Unbonded Overlay over Existing Concrete Pavement with Fabric Interlayer

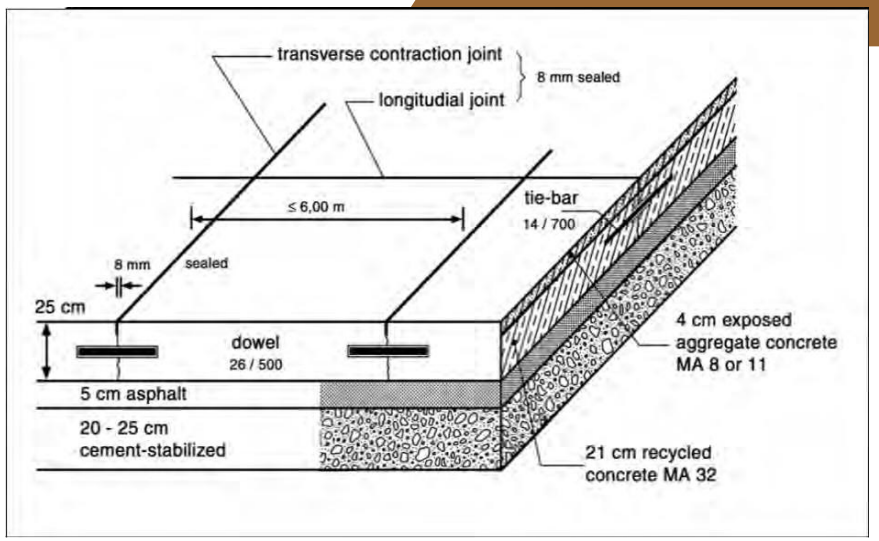
Two Lift Concrete Pavement

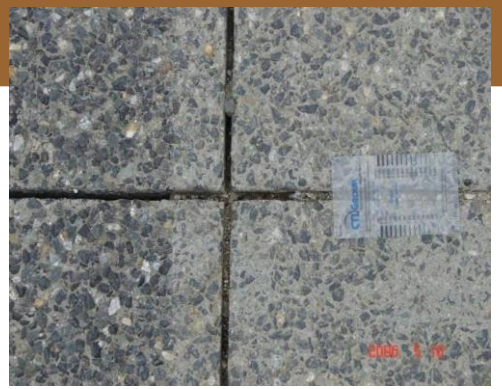
2-Lift Concrete Pavement – Indian Approach Under Development

Top lift with exposed aggregate

Bottom lift with recycled aggregate







Two Lift Concrete Pavement

2-Lift Concrete Pavement Construction

- **Two-lift concrete placement to maximize the use of recycled materials**
  - Top lift – 50 mm; bottom lift – 230 mm
- **Fractionated Reclaimed Asphalt Pavement (FRAP) as a coarse aggregate replacement in a ternary blended concrete pavement – bottom lift**

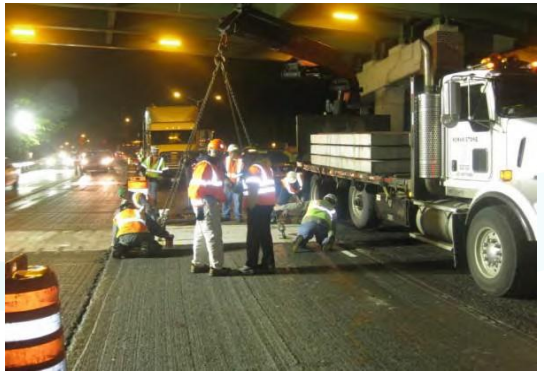
Power Screener for Fractionating RAP

Requires two paving machines & two concrete plants; wet on wet concrete placement

Precast Concrete Pavement Technology

Precast Concrete Pavement Systems (Codal Guidelines Under Development)

- **Pros:**
  - Time Saving
  - Concrete Panels casted in casting yard (precise quality control)
  - No need of slip form pavers
  - Easily repairable & low maintenance cost
  - Longer Life
- **Limitations:**
  - Strict Adherence to Quality Work
  - Zero tolerance needed while laying the precast panels on highway i.e., zero tolerance while profile matching.
  - Skilled labour required
  - Skilled Transportation Required

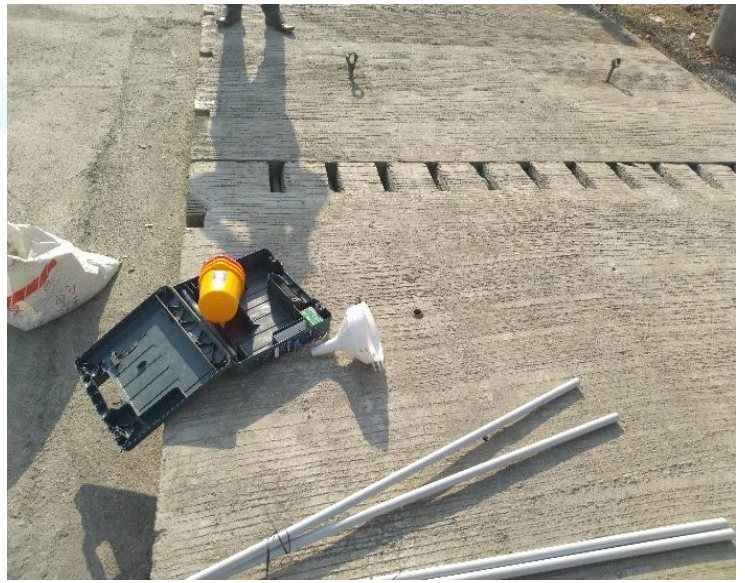


Precast Concrete Pavement Systems (Overview of Pilot Project in Nagpur City)

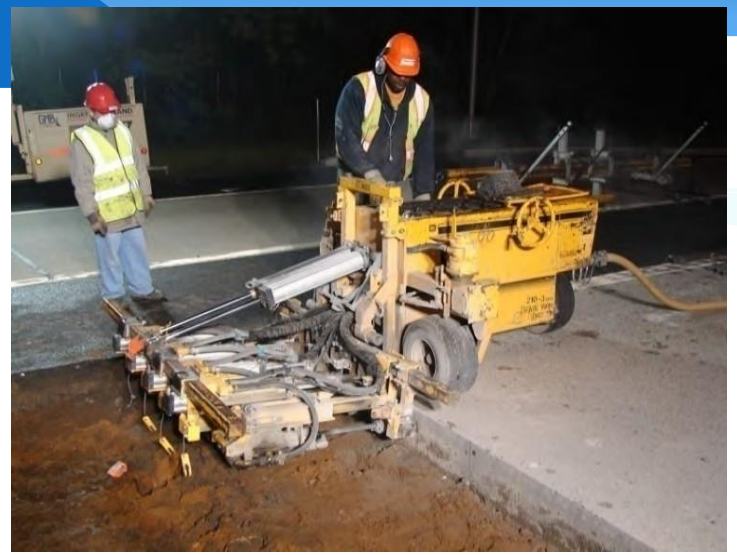
Pilot project of Prestressed Precast Concrete Pavement (PPCP) on Inner Ring road of Nagpur City S.H. 340. Km. 38/040 to 38/340.

Salient Features

	Size of Panel	4.0 m X 3.50 m
1	Thickness of Panel	200.0 mm
2	Grade of Concrete	M-45
3	Dowel Bars 25 mm dia. @250 mm c/c	12 Nos
4	Tie Bars 12 mm dia. @775 mm c/c	5 Nos
5	Prestressing tendens 9.5 mm dia. 7 ply	13 Nos.
6	Prestressing force	108 MT
7	Nominal surface reinforcement 8.0 mm dia. @225 mm c/c in both way @ bottom and At Lifting point Reinforced mesh of size 1.0 m X 1.0 m with 8 mm dia. bars @125 mm c/c at top	60 Kgs.
8	Lifting Hook with threaded 40 mm Nutbolt	4 Nos.
9	Weight of Panel	7.0 MT
10	Grout Admixture	Powergrout NS, 20MPa @ end of 1 day.
11	Rate of Prestressed Precast Concrete Pavement	Rs. 2765.00/ Sqm.
12	Rate of pavement quality concrete (PQC)	Rs.3052.00/Sqm.



Accelerated M&R Technologies



Repair Applications

International Experiences

15 to 20 repairs/night

Thank You

Can Reach Me at:

Atasi.d@grinfra.com