



**Global Road Infratech
Summit & Expo**

**05-06 FEBRUARY 2026
Hotel The Ashok | New Delhi | India**



Stone Matrix Asphalt (SMA): A Case Study

Developing a Standard Operating Procedure Based on Field Learnings

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²**Vertis Infrastructure Trust**: Ashish Patil², Annamalai Muthu², Dr. Zafar Khan²

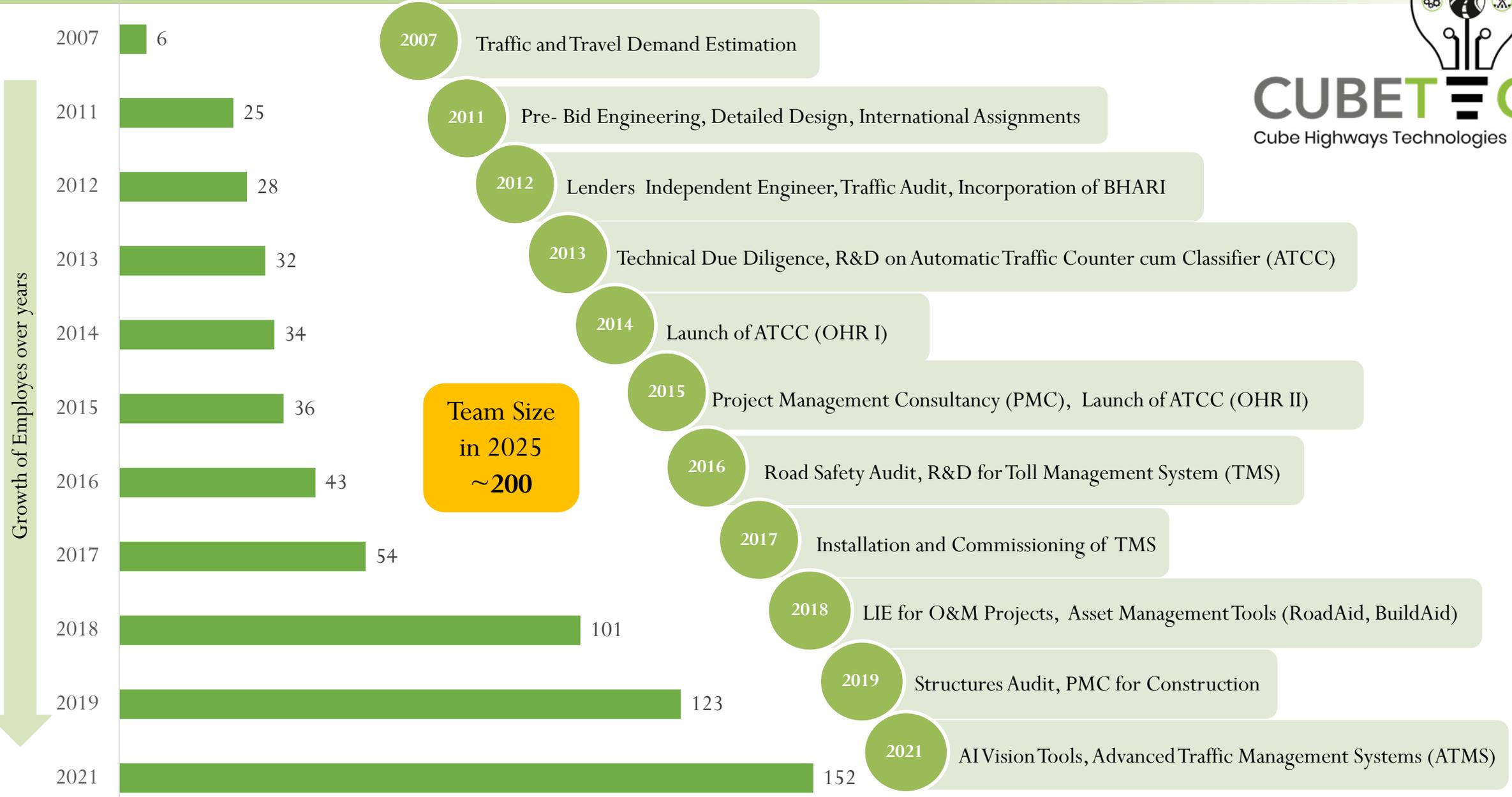
Presenter: Abhishek Gadekar, AVP-Pavements, Cube Tech

5th February 2025

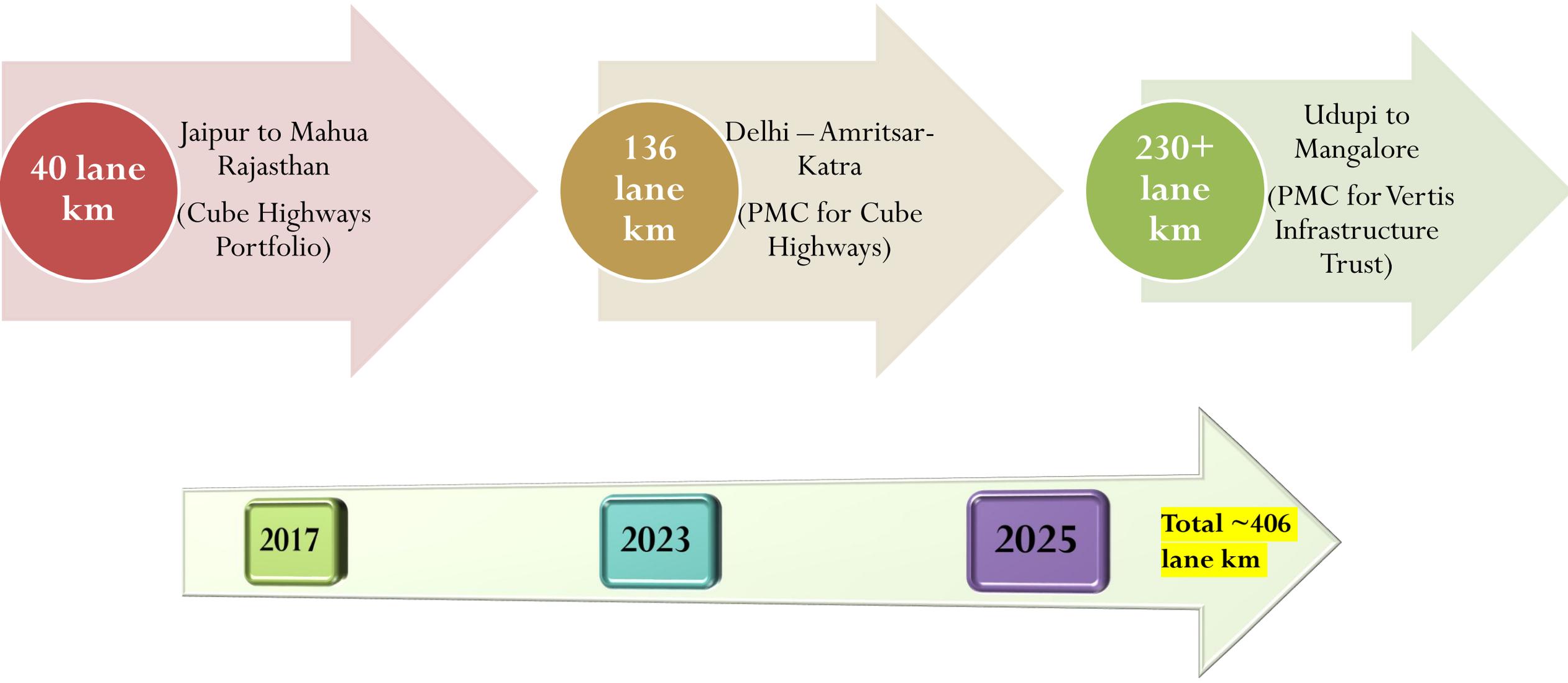
Cube Tech's Growth Story



CUBETECH
Cube Highways Technologies Pvt. Ltd.



Cube Tech's Success Story: Stone Matrix Asphalt (SMA) Overlaying





About SMA



Study of Existing Pavement and Preparation of Maintenance Strategy



Material Research & Mix Design of SMA



Plant and Machinery Modification



Quality Control & Quality Assurance



Challenges and Remedials



SMA Mix with Varying Lime content



Summary

About SMA ?

IRC:SP:79-2023

SPECIFICATIONS FOR STONE MATRIX ASPHALT

(First Revision)



INDIAN ROADS CONGRESS
2023

- Codal provision of SMA IRC:SP:79 was first published in June-2008
- First Revision of **IRC:SP:79-2023 published in December-2023**
- Following key changes were made in this revision-
 - **Use of PMB is suggested instead of VG grade** considering heavy trafficked roads in India
 - Discourage the use of excess **Hydrated Lime and limited to 4%**
 - In place of Hydrated lime, can use **baghouse filler** to meet the requirement of mix
- **Initial or breakdown rolling – Vibratory**
- Intermediate rolling – Smooth wheel or Vibratory
- Final of finished rolling – Smooth wheel
- **94%** Compaction required
- Apart from general tests, **drain down** test is required to ensure – **resistance against bleeding** due to **rich bituminous mix**.



SMA _ Mix Ingredients



Why SMA Fails multiple times in India???



Severe Bleeding



Severe Rutting



Patches and Unevenness



Corrective Action
➔



Standard Operating Procedure (SOP)

- Literature Review
- Domestic and International Codal Provisions
- Material Research and Source Finalizations

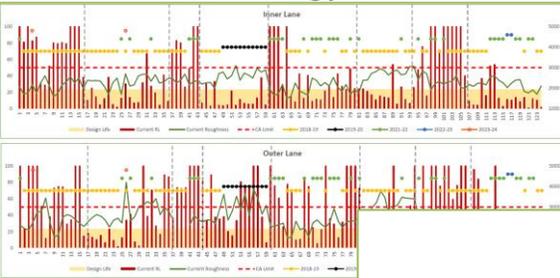
- Preparation of Trial Procedure and Field Implementation

- Field Learnings and Document the work
- Preparation of Learning Based SOP





Pavement Study and Preparation of Strategy



Material Research and Finalization

VIATOP[®] premium
Das Pellet.

Pellets for Fiber Modified Asphalt Mixtures

VIATOP[®] premium is a pelletized blend of:
 90 % by weight ARBOCEL[®] ZZ 8/1
 10 % by weight Bitumen 50/70



Plant and Machinery Modification

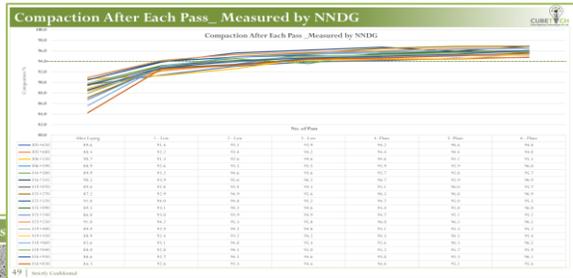


Challenges and Remedials

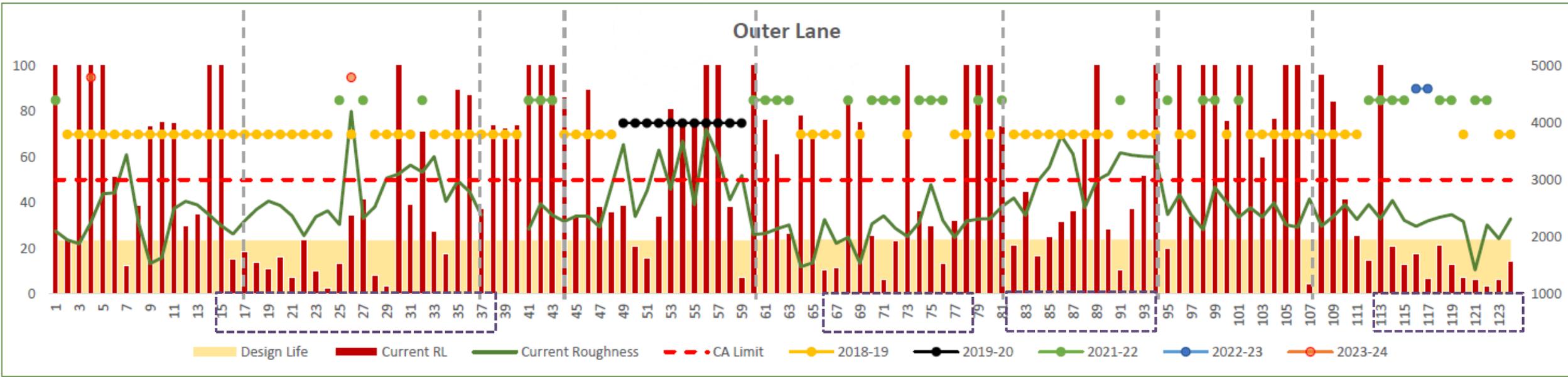
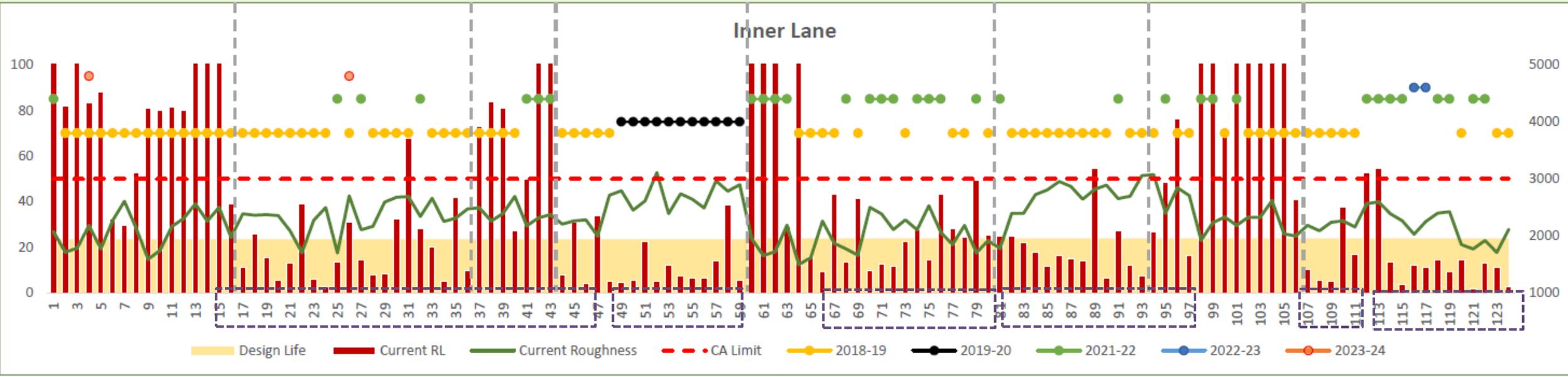
SMA - Issues Identification (Bleeding) - Initial Phase



Quality Control/ Checklists



Pavement Study: Right Road, Right Treatment, Right Time – RRR Concept



Distress on Existing Pavement / Post Milling Surface



Post Milling Surface



Post Milling Surface



Existing Pavement



Post Milling Surface



Post Milling Surface



Post Milling Surface

- **TO mill and fill with DBM** at these locations to treat underlying distressed layer for betterment of pavement life



Material Research _ Quality of Fiber

Sr. no.	Characteristic parameter	Test Method	Result	Limit
1	Size and shape test	IRC: SP:79	4.2 mm	0.25 – 6.0 mm length
2	Drain down test with mix	IRC: SP:79	0.015 %	0.03 %
3	Moisture content	IRC: SP:79	3.5 %	≤ 5.0 %
4	Oil absorption	IRC: SP:79	4.8 times	≥ 4 times its own weight



Fiber pellet's structure before and after pellet open

VIATOP® premium
Das Pellet.

Pellets for Fiber Modified Asphalt Mixtures

VIATOP® premium
is a pelletized blend of:

- 90 % by weight**
ARBOCEL® ZZ 8/1
- 10 % by weight**
Bitumen 50/70

Material Research _ Quality of Lime and Dosing

Sr. No.	Characteristic Parameter	Test Method	Result	Limit
1	Fineness test	IS:1514	94.5% Passing	85–100% passing 75-micron sieve
2	Specific gravity	IS:1514	2.235	Not specified (usually 2.0–2.4)
3	Phenolphthalein test for hydrated lime	IS:1514	Turns pink	Must turn pink at pH 8.2
4	Iodine method for purity verification	IS:1514	Sample shows no darkness	Sample must not stain dark





Quality of Aggregate & Bitumen



Unnamed Road
Udupi
Mysore Division
Karnataka
Altitude:-46.6m
Mar 29, 2024 17:36:04

Bitumen				
Sr. no.	Property	Test Results	MoRTH Specification Limit	Pass or Fail
1	Specific Gravity at 27 ° C (G_b)	1.037	Min- 0.99 g/cc	Pass
2	Penetration at 25 ° C, 0.1mm, 100g, 5 Sec	42	Min- 35 (0.1mm)	Pass
3	Softening Point	53.45	Min- 50 °C	Pass
4	Absolute Viscosity	4307.53	3200- 4800 Poise	Pass

Aggregates				
Sr. no.	Property	Test Results	MoRTH Specification Limit	Pass or Fail
1	Aggregate Impact Value (AIV)	17.8 %	18% (max.)	Pass
2	Los Angeles Abrasion Value (LAV)	24.3 %	25 % (max.)	Pass
3	Shape Index Test (IE+FI)	18.14 %	30 % (max.)	Pass

Sr. no.	Property	Specific Gravity & Water Absorption of Aggregates						
		Hot Bin No	Hot Bin Sieve Size	Blending Proportion	Bulk Sp. Gravity	Apparent Sp. Gravity	Water Absorption	
		4	Bin-1	16-09 mm	$P_1 = 73.0$	$G_1 = 2.683$	$G_{a1} = 2.700$	0.24
			Bin-2	09-04 mm	$P_2 = 5.0$	$G_2 = 2.667$	$G_{a2} = 2.706$	0.53
			Bin-3	04-Down	$P_3 = 15.0$	$G_3 = 2.647$	$G_{a3} = 2.709$	0.87
5	Coating Value (IS 6421 : 1971)	>95%		95% (min.)		Pass		
6	Coating Value (IS 6421 : 2024)	>95%		95% (min.)		Pass		



13.2064206N 74.8761535E
Altitude:-47.17m
India
May 3, 2024 11:41:48



06-Apr-2024 11:45:23 pm
Unnamed Road
Udupi
Mysore Division
Karnataka
Altitude:-46.6m

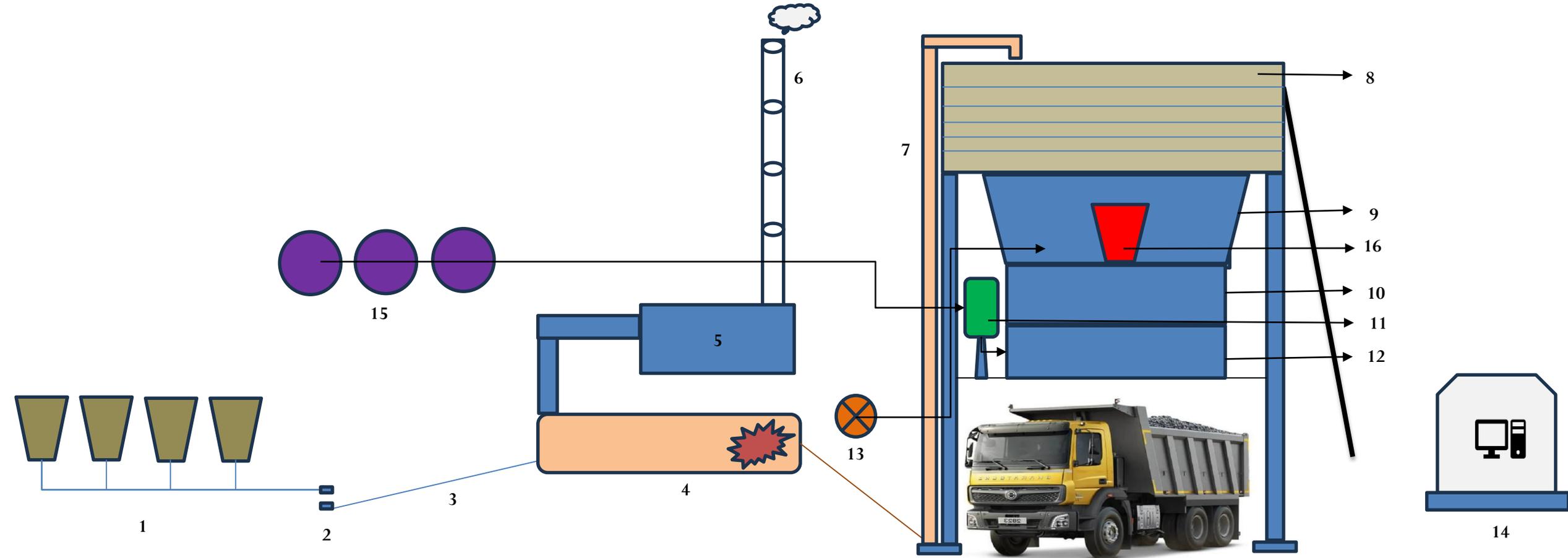
Lime				
Sr. no.	Property	Test Results	MoRTH Specification Limit	Pass or Fail
1	Specific Gravity at 27 ° C (G_b)	1.037	Min- 0.99 g/cc	Pass



14-Feb-2024 11:0

SMA Mix Production

HMP Production Unit Schematic Diagram



1. **Cold Bine Feeder** 2. Pre-Separator 3. Cold Feed Conveyor 4. Dryer Drum 5. Primary Pollution Device 6. Exhaust Stack 7. Hot Elevator 8. Screening unit 9. Hot Bins
10. Weigh box 11. **Bitumen unit** 12. Mixing unit (Pugmill) 13. **Mineral Filler (Lime)** 14. Control unit 15. **Bitumen Storage tank** 16. **Fiber Hooper**



Modification in Plant for SMA Production



Lime Dosing Unit



Fiber Dosing Unit



Mar 16, 2024 09:39:24
13.20596814N 74.87669288E ±5.69m
Karnataka
UTPL - Filler Elevator



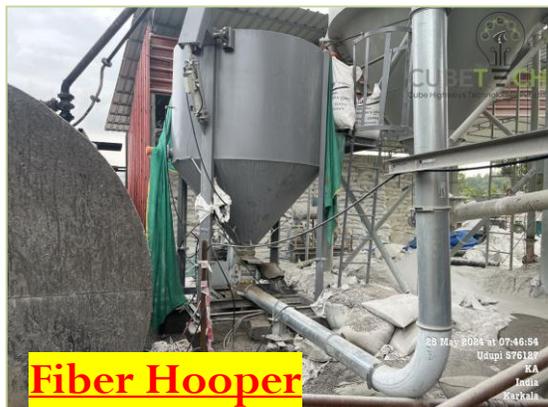
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Karnataka
UTPL - SMA Mix



28 May 2024 at 07:44:11

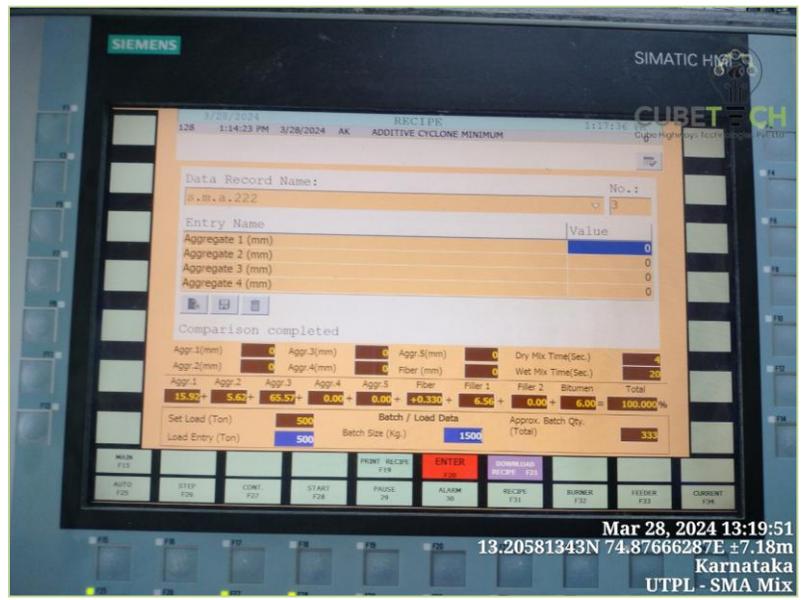


Fiber Hooper

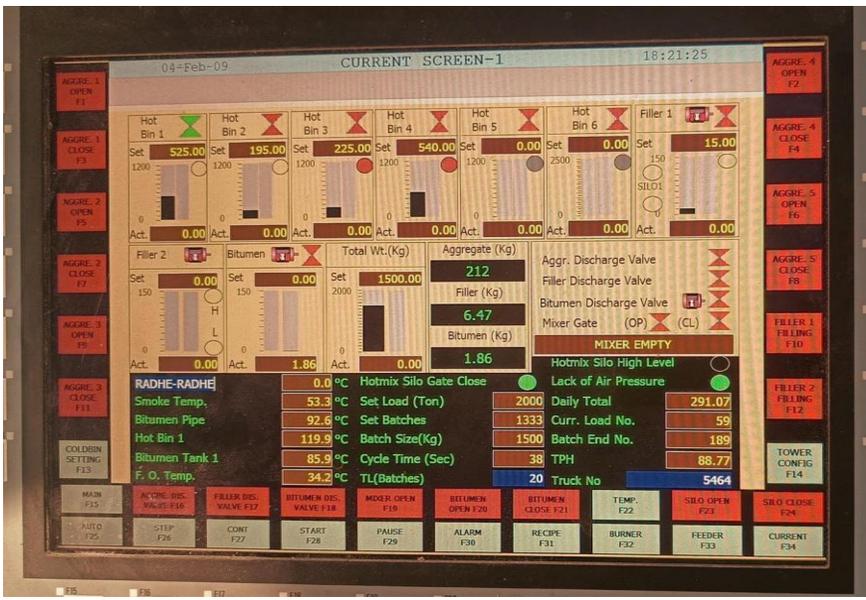


28 May 2024 at 07:46:54
Udupi 576187
KA
India
Karkala

Plant Batching & SMA Mix Production



Mix Recipe



Mix Proportioning/ Weighing



Three Point Loading



Mix Coating



Mix Temperature

47.30	0.00	4.90	0.00	1140.07			
15:55:41	187.15	794.14	0.00	77.23	70.38	1188.04	51 30
	55.23	0.00	4.91	0.00	1118.66		
15:56:48	164.23	807.95	0.00	79.49	73.13	1201.36	63
	71.69	0.00	4.87	0.00	1128.23		
15:57:48	181.27	807.07	0.00	75.73	72.20	1210.96	45 32 3
	69.63	0.00	5.06	0.00	1138.76		

Agg 1 :	75470.17 kg	Filler 1 :	32926.72 kg
Agg 2 :	26356.79 kg	Filler 2 :	0.00 kg
Agg 3 :	355367.88 kg	Batch Wt :	492034.85 kg
Agg 4 :	0.00 kg	Bitumen :	30489.39 kg
Agg 5 :	0.00 kg	Total Wt :	522524.24 kg
Agg 6 :	1913.29 kg		

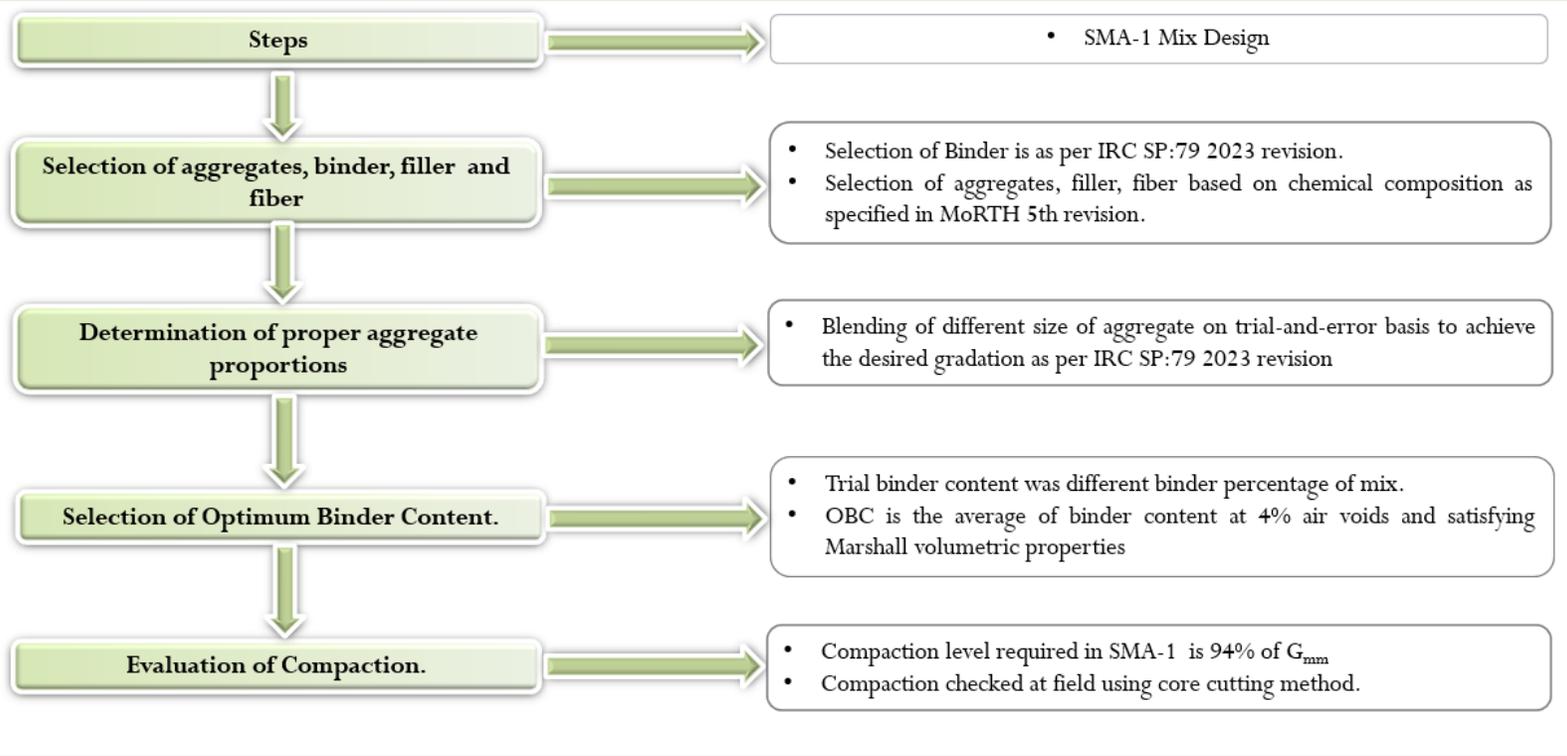
Mar 26, 2024 08:27:24
13.20619803N 74.87627835E ±36.46m
Karnataka
UTPL - SMA Mix

Batch Reports

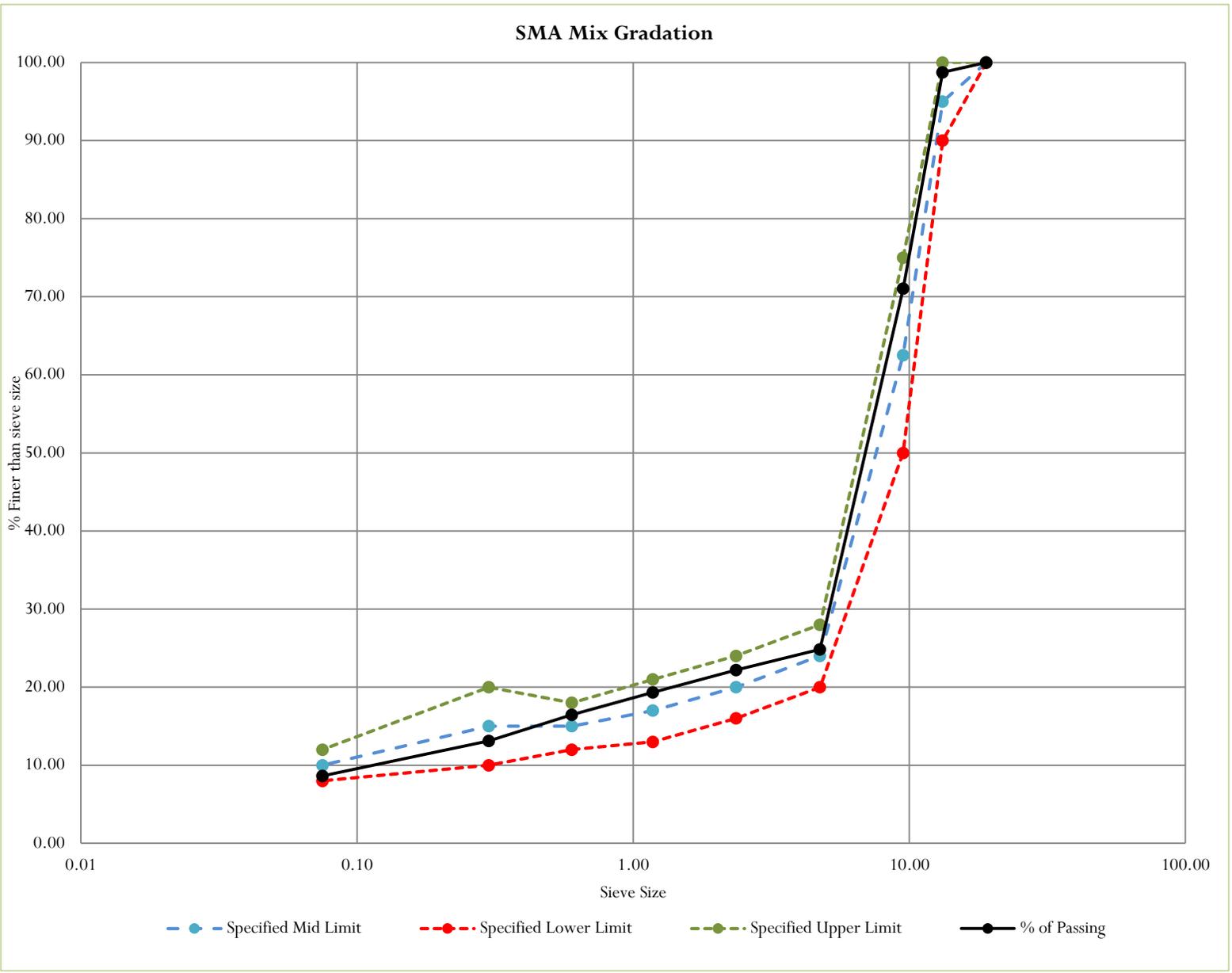
SMA Mix Design



SMA _Process of Marshall Mix Design



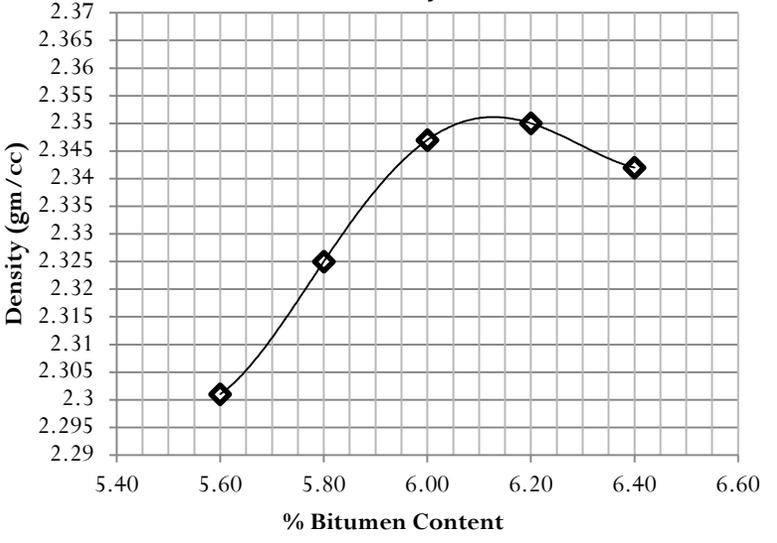
Mix Gradation (Blending with 7% Lime)



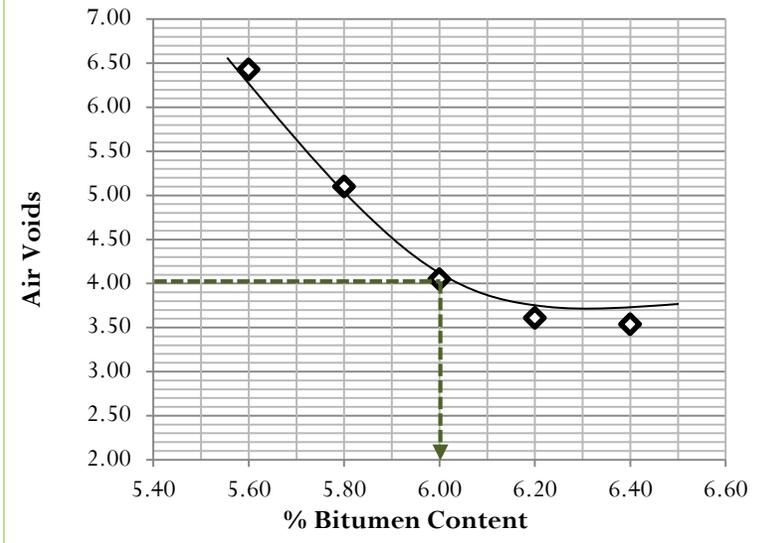


SMA _ Marshall Mix Design (7% lime)

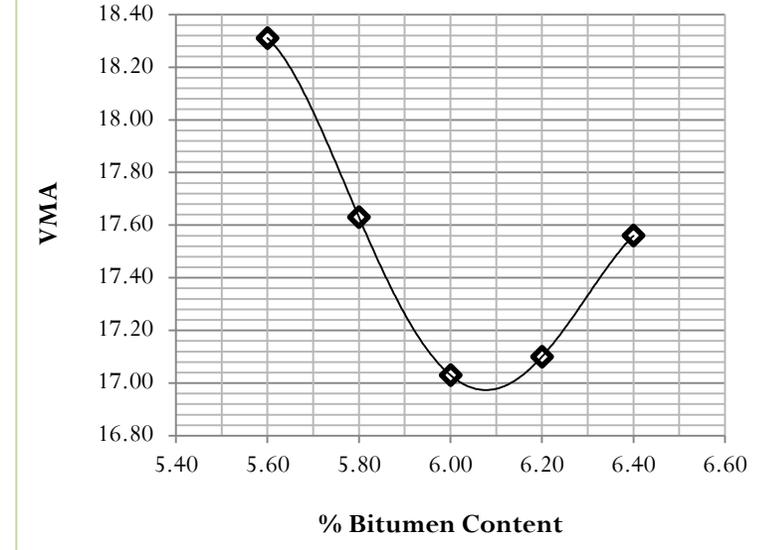
Density



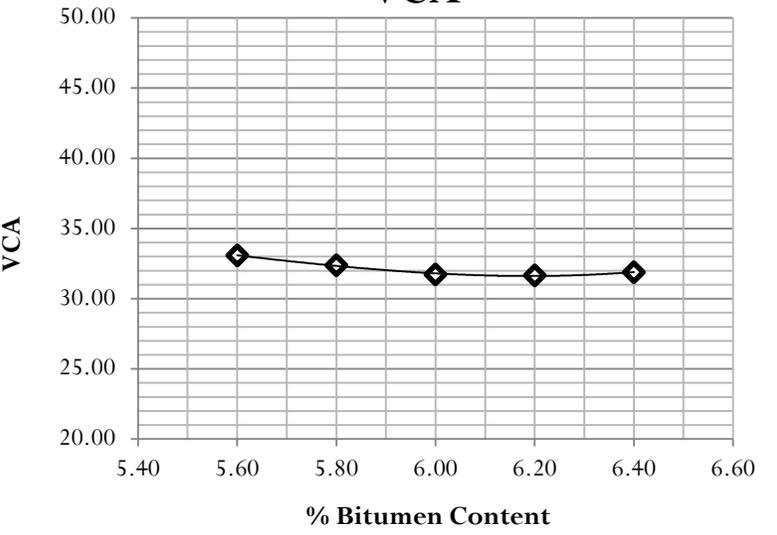
Air voids



VMA



VCA



OBC Determination (IRC SP 79: 2023, MS-2)										
Properties	Optimum Bitumen Content (%)	Fiber (%)	Density (g/cc)	Gmm	Air Void (%)	VMA (%)	VCA (%)	VCA (%) by dry rodded	Drain Down (%)	TSR
Limits	-	0.3%	-	-	3-5	Min. 17%	<VCA (dry)	-	Max. 0.3%	Min. 85%
Results	6.00	0.3%	2.347	2.446	4.05	17.03	31.74	45.27	0.20	92%

Note: At 6% bitumen, 4% air void was observed, and all other properties are satisfying the MoRTH requirement, OBC – 6% confirmed.

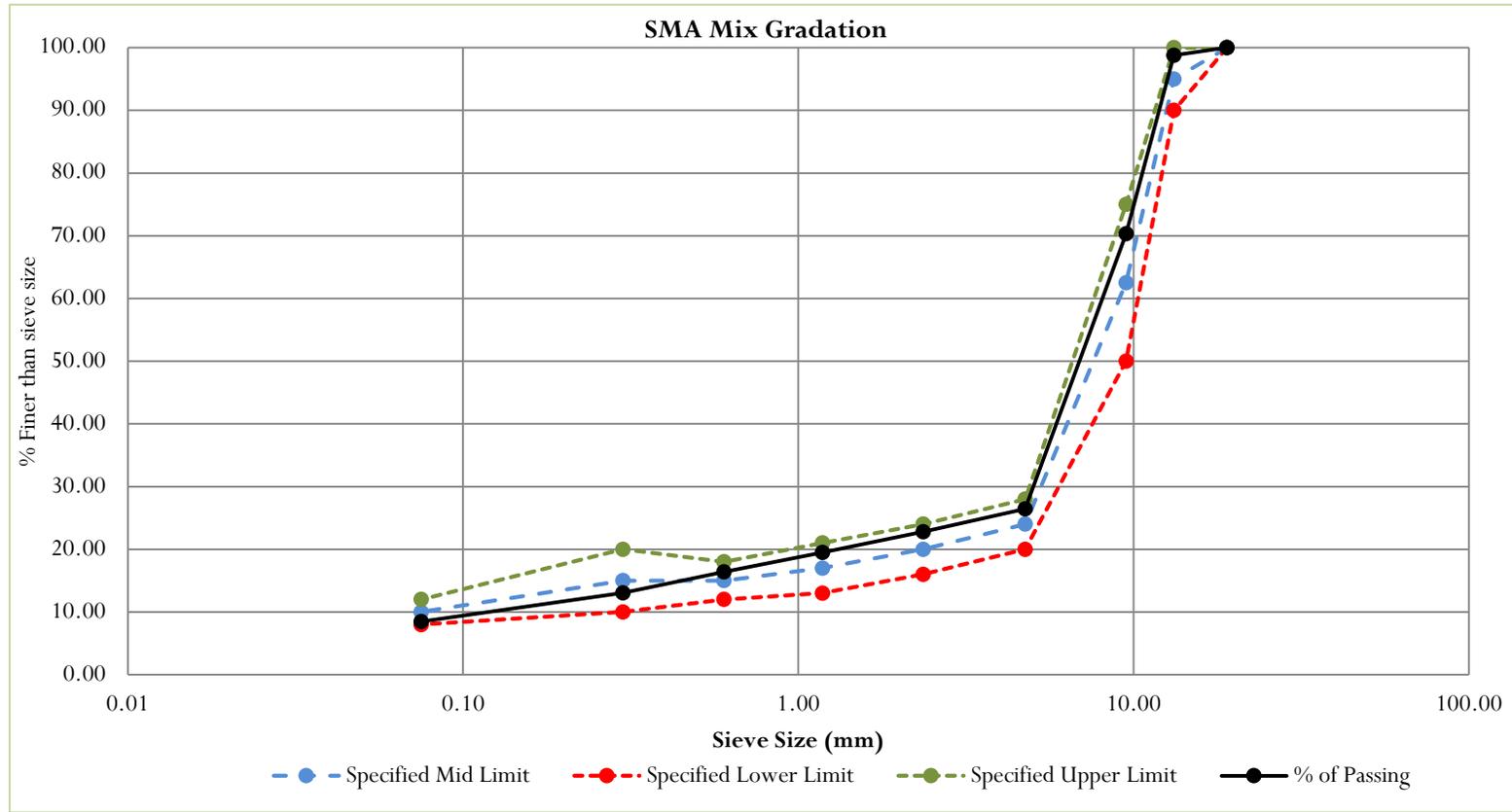


Mix Design (3% Baghouse Filler + 4% Lime)

OBC Determination (IRC SP 79: 2023, MS-2)

Properties	Optimum Bitumen Content (%)	Fiber (%)	Density (g/cc)	Gmm	Air Void (%)	VMA (%)	VCA (%)	VCA (%) by dry rodded	Drain Down (%)	TSR (%)
Limits	-	0.3%	-	-	3-5	Min. 17%	<VCA (dry)	-	Max. 0.3%	Min. 85%
Results	6.00	0.3%	2.344	2.444	4.09	17.14	32.70	45.27	0.20	90%

Note: At 6% bitumen, 4% air void was observed, and all other properties are satisfying the MoRTH requirement, OBC – 6% confirmed.



Mix Design with Varying Lime Content

Mix Properties	% Lime Content					
	0%	2%	4%	6%	7%	8%
Bitumen Content (%)	6.0	6.0	6.0	6.0	6.0	6.0
Retained Indirect Tensile Strength Ratio (%)	86	87	90	90	92	89
Density (Gmb) g/cc	2.349	2.346	2.345	2.337	2.347	2.333
Max. Specific Gravity (Gmm)	2.450	2.449	2.445	2.447	2.446	2.444
Air void (Va)	4.12	4.21	4.09	4.5	4.05	4.54
Voids in mineral Aggregate (V.M.A%)	17.0	17.1	17.1	17.4	17.03	17.5

Mix Volumetric and Marshal Properties:

- Mixes with 0–8% lime all met specifications.
- 7% lime mix showed the **highest TSR value**.

Cost Saving by Varying Lime Content

**Cost of one-ton Hydrated Lime
(Rupees)**

₹ 5,600.00

**Cost of one-ton SMA mix
(Rupees)**

₹ 10,000.00 (0 % Lime)

**Percentage of Hydrated lime
used in SMA (%)**

0%

2%

4%

6%

8%

**Quantity of Hydrated Lime
used in each ton of SMA Mix**

0

0.02

0.04

0.06

0.08

**Cost of hydrated lime used in
each ton of SMA Mix (Rupees)**

₹ 0.00

₹ 112.00

₹ 224.00

₹ 336.00

₹ 448.00

**Cost of SMA mix used in each
ton of Different lime content
(Rupees)**

₹10,000.00

₹10,112.00

₹10,224.00

₹10,336.00

₹10,448.00

- **Mix Volumetric and Marshal Properties:**
 - Mixes with 0–8% lime all met specifications.
 - 7% lime mix showed the **highest TSR value**.

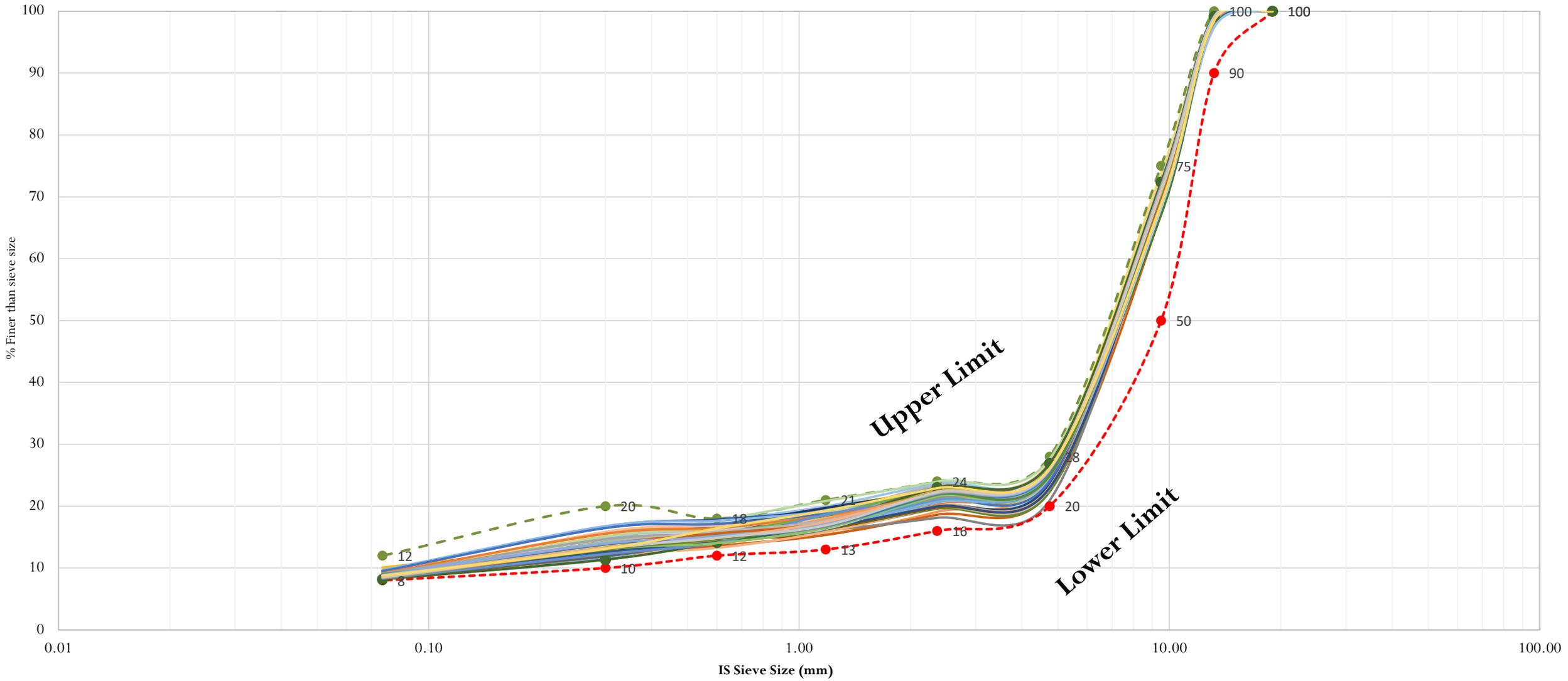
- **Lower Lime Content (0–2%):**
 - Comparable performance to higher lime mixes.
 - Allows **partial replacement with rock filler** → cost-effective option.

- **Higher Lime Content – Challenges:**
 - **Excessive Alkalinity: pH may rise too high, over-stiffening the binder.**
 - May cause **dry, harsh mixes** → compaction issues.
 - Risk of **over-stiffening & cracking** under loads.
 - **Higher cost** per ton.

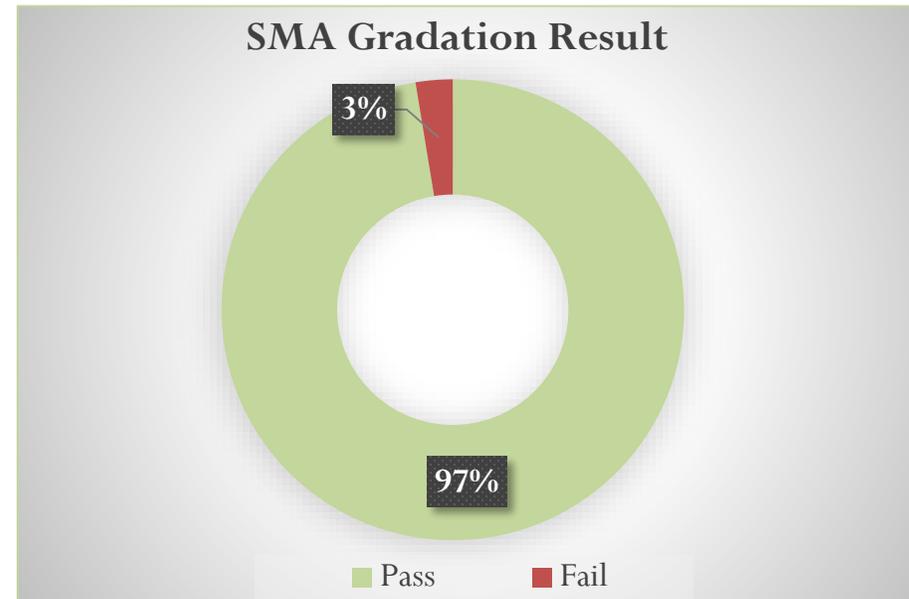
- **Economic Impact:**
 - Every **2% reduction in lime saves ₹112/ton**.
 - Quarry fillers with proper properties → sustainable & cost-effective alternative.

Laboratory Quality Control & Quality Assurance of SMA Mix

Mix Gradation_SMA

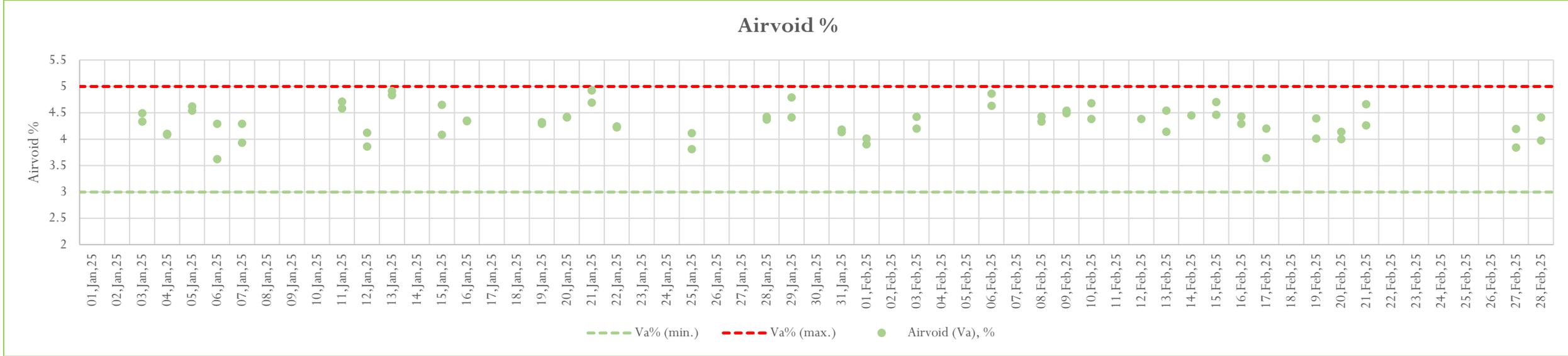
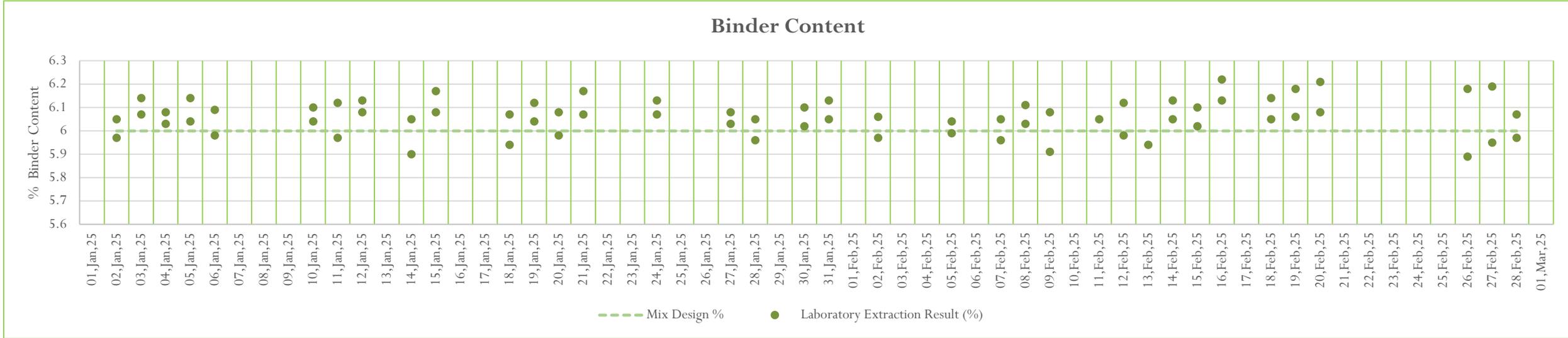


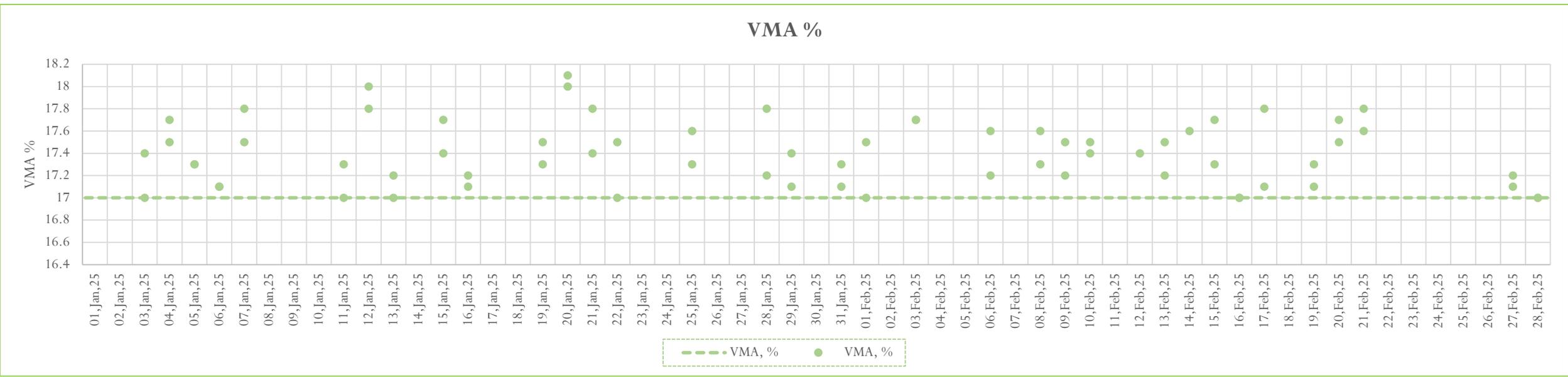
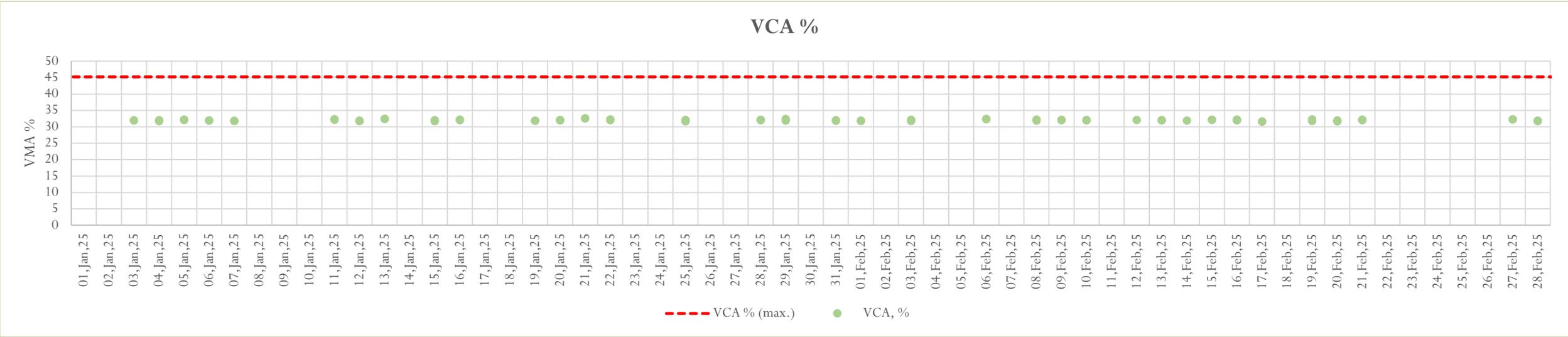
- **Short of Fines/Filler in mix:** During the initial stages of the production, we experienced issues similar to those seen in earlier SMA projects, where the fines content fell short of meeting the specified filler requirements for the SMA mix.



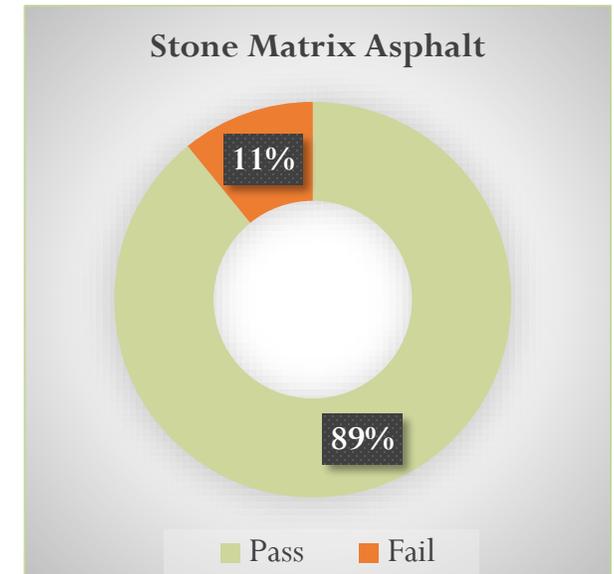
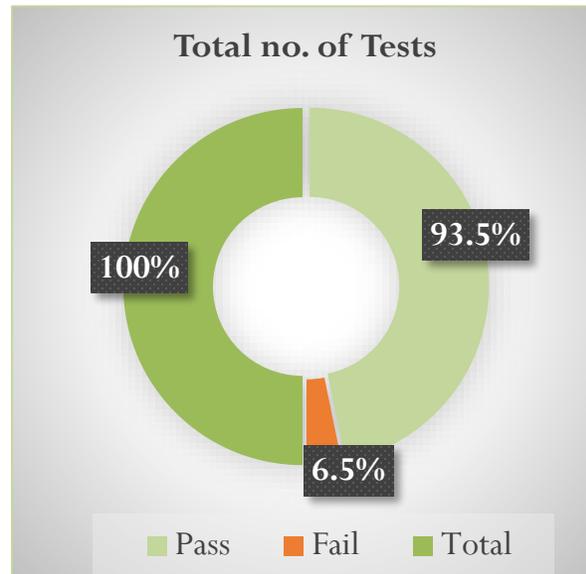
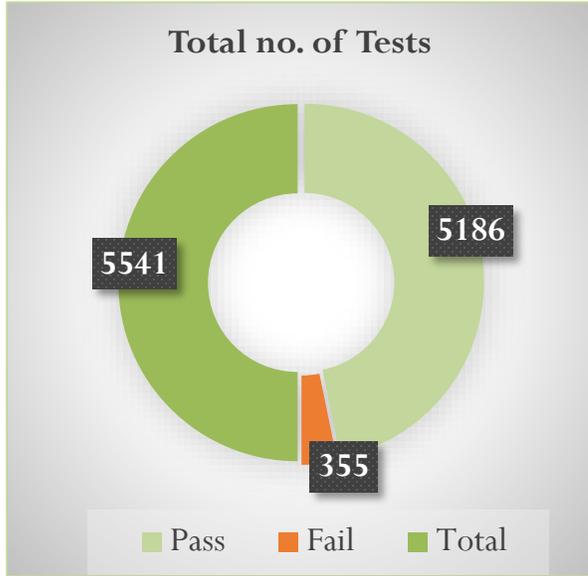
- ✓ **Corrective Action:** Considering the severity of this issue, PMC team has proactively adjusted the aggregate gradation to ensure meeting filler content requirements for SMA mix.

Binder Content & Marshall Results _ SMA





Overall Tests (Pass vs Fail)



Field Quality Control & Quality Assurance of SMA Mix

SMA _ Stone to Stone Contact _ Aggregate Skeleton



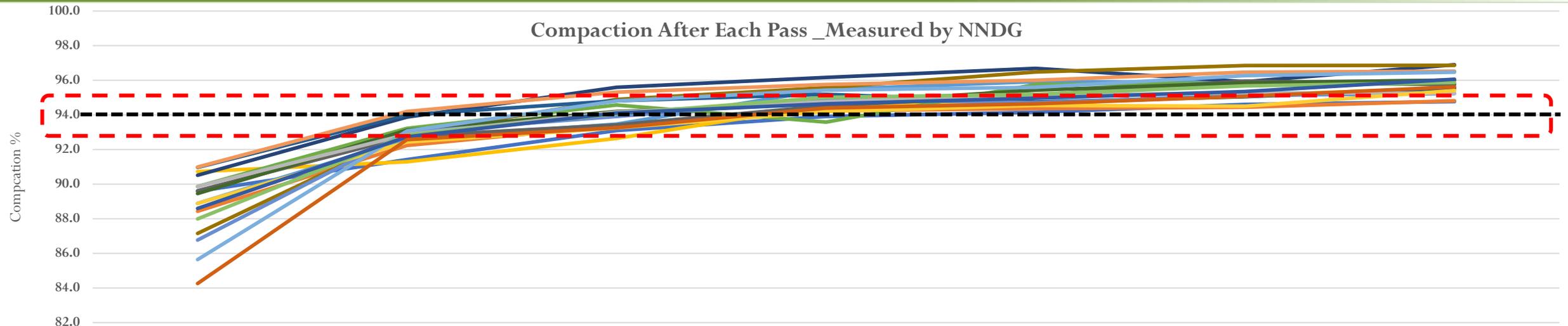
- NNDG compaction at each 20 m intervals
- Core compaction tests 5 no. of cores in each km
- Stone – Stone Contact

21 Apr 2024 4:25:52 pm
Bramavara
Mysore Division
Karnataka
309+550. 2.0 LHS

May 3, 2024 16:02:02
13.36955265N 74.74577942E ±3.79m
Karnataka
UTPL - Core Cutting for SMA
Km 315.885 to 316.950 LHS
at km 316.100 (Offset - 3.9 Mtr)

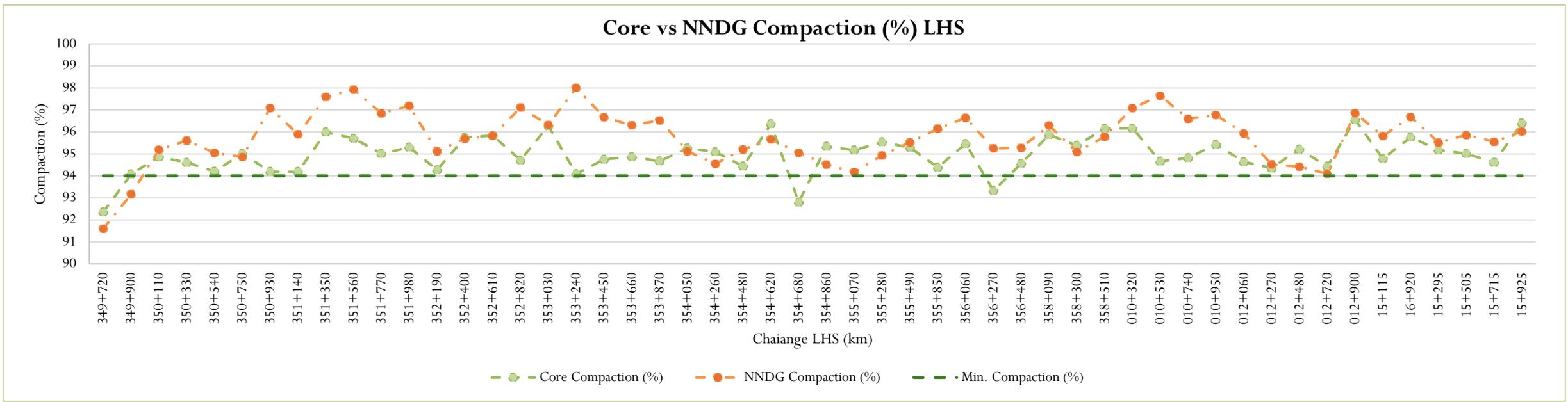
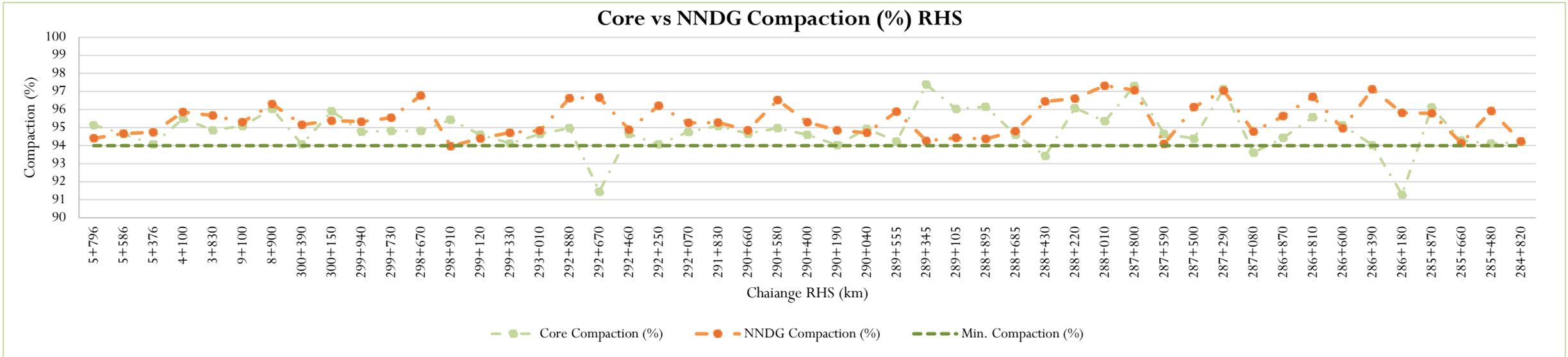


Compaction After Each Pass _ Measured by NNDG



	No. of Pass						
	After Laying	1 - Low	2 - Low	3 - Low	4 - Plane	5 - Plane	6 - Plane
305+650	89.6	91.4	93.1	93.9	94.2	94.6	94.8
305+688	88.4	92.2	93.4	94.2	94.4	94.4	94.8
306+550	90.7	91.3	92.6	94.6	94.6	95.1	95.5
306+590	88.9	92.6	93.5	95.5	95.9	95.9	96.0
316+500	89.9	93.2	94.6	93.6	95.7	95.8	95.7
316+545	90.5	93.9	95.6	96.2	96.7	95.9	96.9
319+070	89.6	92.8	93.4	94.5	95.1	96.0	95.7
325+270	87.2	92.9	94.9	95.6	96.5	96.8	96.9
325+320	91.0	94.0	94.8	95.2	94.7	95.0	95.5
325+090	89.5	93.1	94.2	94.6	95.4	95.8	96.0
325+240	86.8	93.0	93.9	94.9	94.7	95.1	95.2
323+250	91.0	94.2	95.3	95.8	96.0	96.5	96.5
319+400	89.9	92.9	94.2	94.8	95.1	95.3	95.2
319+350	88.9	92.4	93.2	94.2	94.5	94.5	95.4
318+060	85.6	93.1	94.8	95.4	95.6	96.3	96.5
318+040	88.0	92.8	94.1	95.0	95.2	95.7	95.9
316+950	88.6	92.7	94.1	94.6	95.0	95.3	96.1
316+830	84.3	92.6	93.3	94.4	94.6	95.1	95.6

Compaction of Compaction _ SMA Core Compaction Vs Measured by NNDG

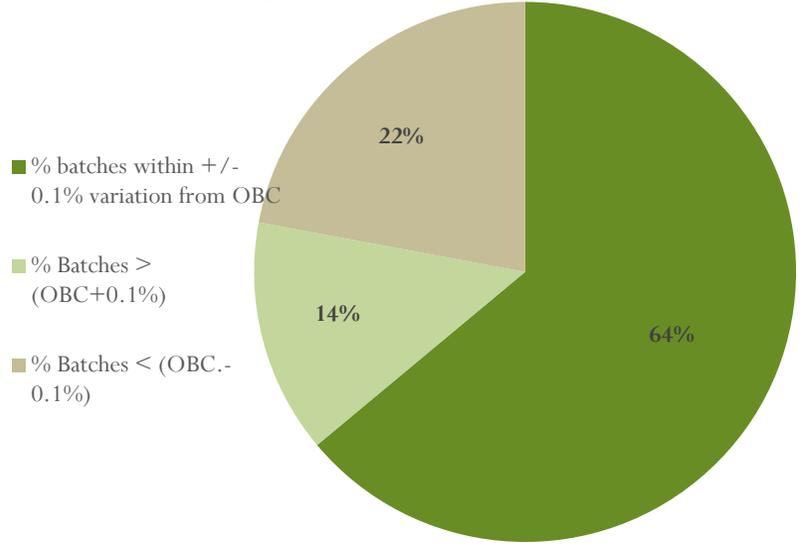


Batch Report Analysis of System Generated Report

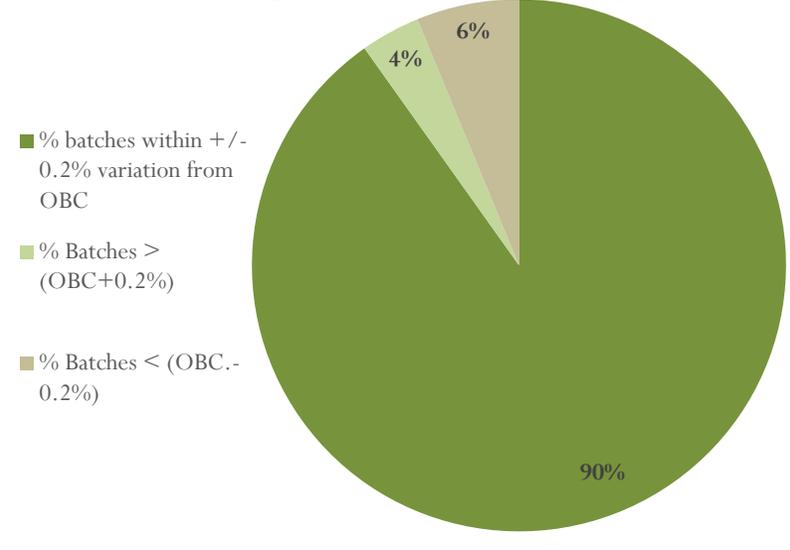


Batch Report Analysis as per ASTM D995

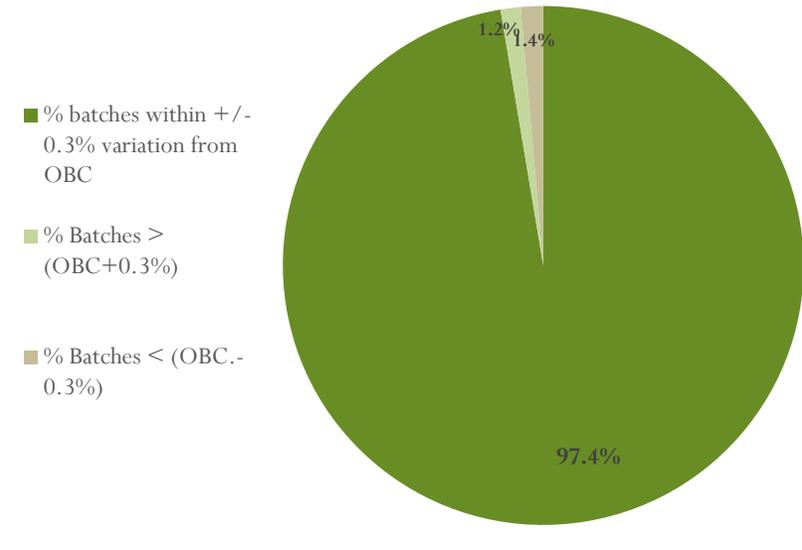
HMP Batch Report Analysis (Tolerance OBC+/-0.1%)



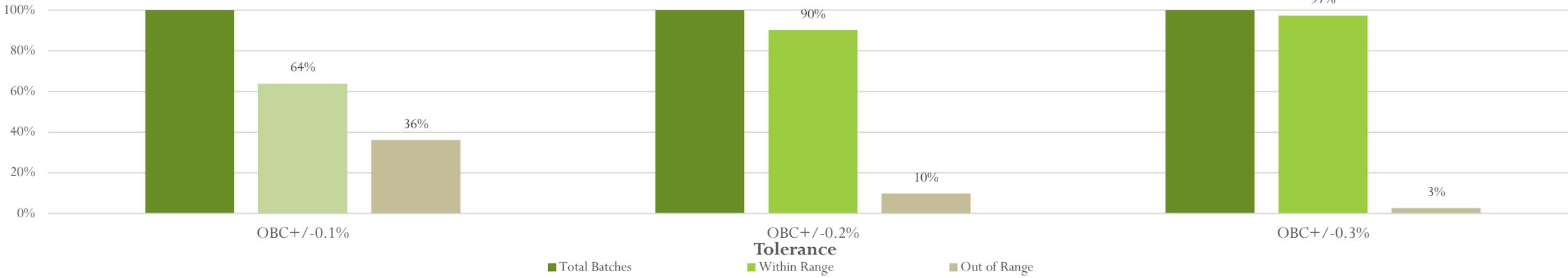
HMP Batch Report Analysis (Tolerance OBC+/-0.2%)



HMP Batch Report Analysis (Tolerance OBC+/-0.3%)



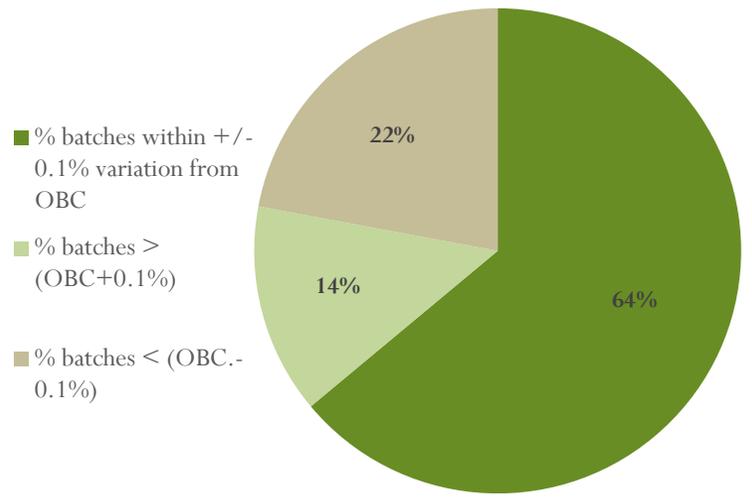
Batch Report Analysis _ Binder Content



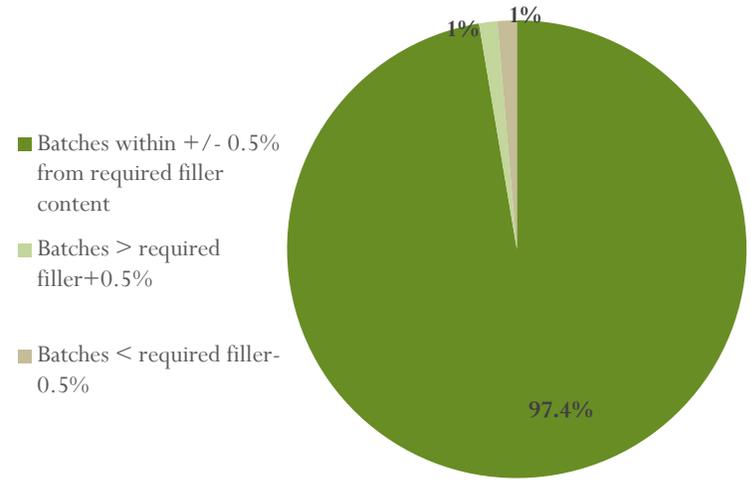
*ASTM D995

Batch Report Analysis as per ASTM D995

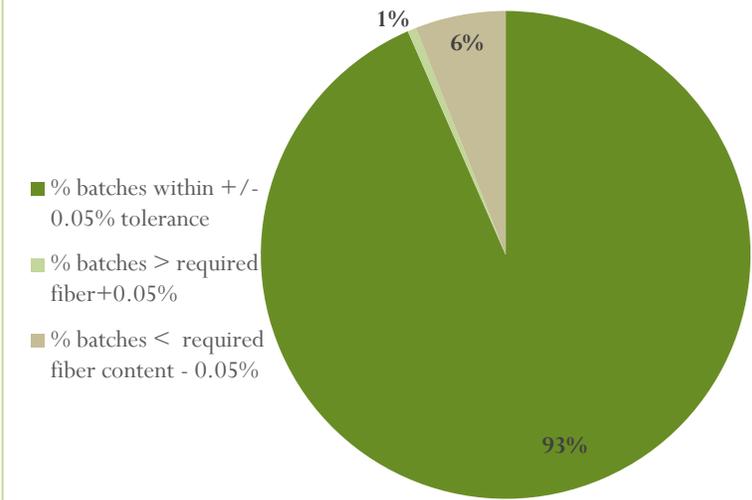
HMP Batch Report Analysis _ Binder Content



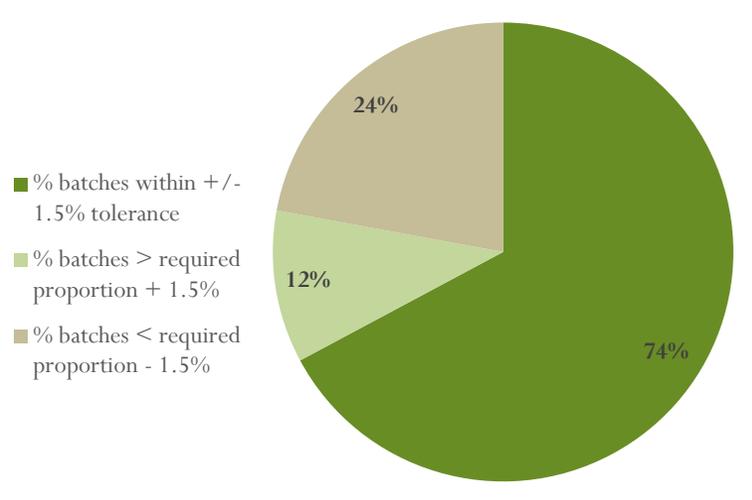
Batch Report Analysis _ Filler Content



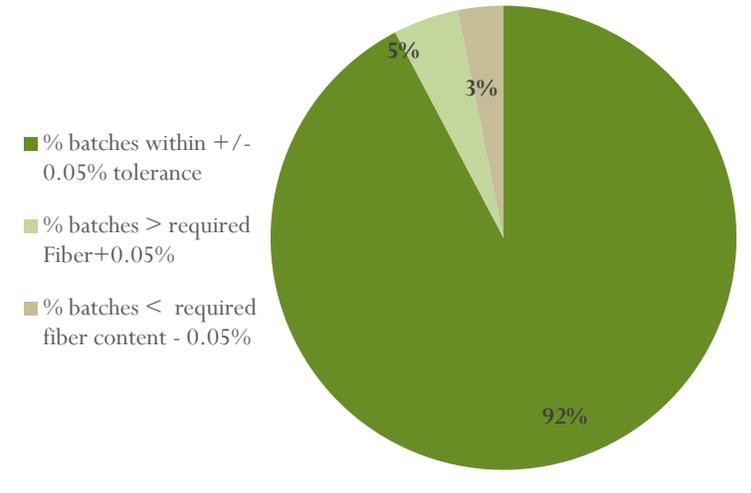
Batch Report Analysis _ Fiber Content



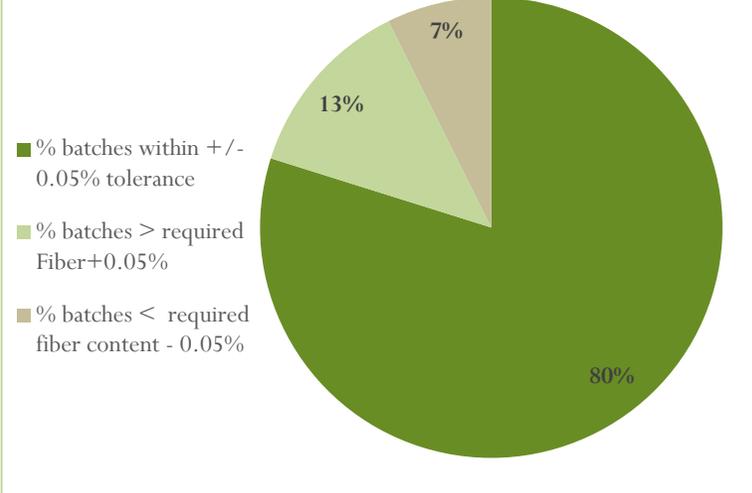
Batch Report Analysis_ Aggregate 10 mm +



Batch Report Analysis_ Aggregate 5-10 mm



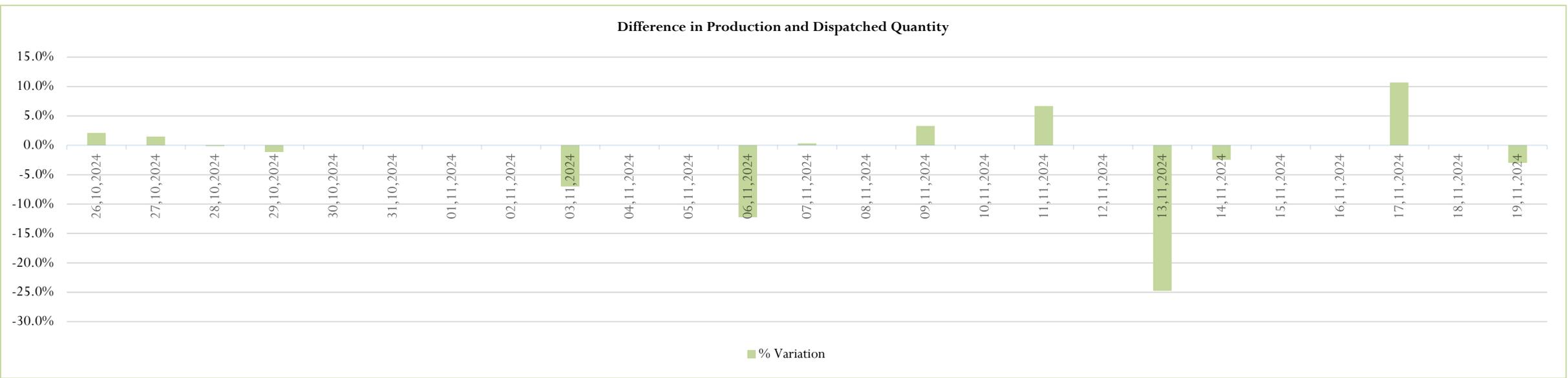
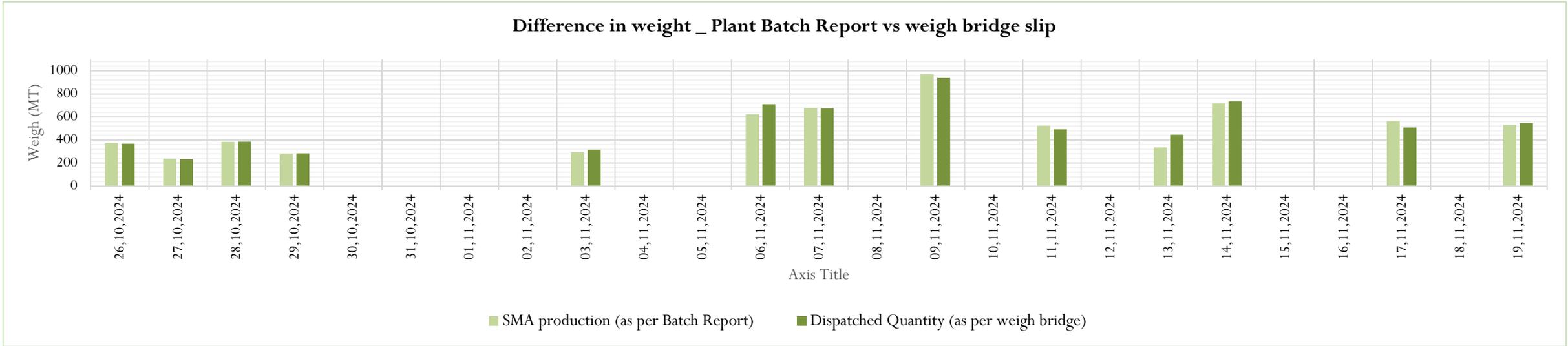
Batch Report Analysis_ Aggregate 5 mm down



Validation of Weighing & Reconciliation



Validation of Weight (Plant Report Vs Weigh Bridge)





Bitumen Stock Details & Reconciliation

Particulars	Month-wise Bitumen Requirements as per Mix Design (MT)													
	Jan'24	Feb'24	Mar'24	Apr'24	May'24	Jun'24	Oct'24	Nov'24	Dec'24	Jan'25	Feb'25	Mar'25	Apr'25	May'25
Month wise VG-40 requirements	44.4	9.7	340.8	763.5	849.1	153.7	114.8	694.1	1023.8	1101	1142.8	1181.1	803.6	499
VG-40_Cumulative Requirements	44.4	54.1	394.9	1158.4	2007.5	2161.2	2276	2970.1	3993.9	5094.9	6237.7	7418.8	8222.4	8721.4

Particular	Month-wise Bitumen Stock (Based on shared invoices) (MT)													
	Jan'24	Feb'24	Mar'24	Apl'24	May'24	Jun'24	Oct'24	Nov'24	Dec'24	Jan'25	Feb'25	Mar'25	Apr'25	May'25
Month wise VG-40 details	44.73	26.9	484.3	696.3	807.6	74.6	105.7	751.0	997.4	1110.6	1136.0	1224.2	845.2	397.3
VG-40_Cumulative Stock	44.73	71.7	555.9	1252.2	2059.8	2134.4	2240.0	2991.0	3988.4	5099.0	6235.0	7459.2	8304.4	8701.7

Bitumen Reconciliation (MT) till 30th May'25 updated by adding missing invoices				
Bitumen	As per Mix Design Requirements	As per Invoice Shared by Inckah team	Shortage (+)/ Excess (-) up to May'25	Remarks (As per Shared Invoices till May'25)
VG-40	8721.437	8701.655	19.782	~0.2% (+)

% Variation ~ 0.2%

Challenges & Remedials: Execution

General Issues (Mix Production & Laying)



SMA _ Issues Identification (Bleeding) _ Initial Phase of Working



Proper feeding of Cellulose Fiber in Hopper

- ❑ Initial phase of project, the hopper of cellulose fiber was being choked during feeding, due to the whole hopper was being filled in one time. This was found one of the reason of bleeding in initial phase of working



- ✓ To resolve this issue, one person was deployed to ensure that cellulose fiber must be feed in small quantities and stored carefully to prevent it from moisture. Also, hopper is filled to that level to consume it by end of the day.



Visibility of Fiber Opening in SMA Mix



Mixing Materials	Conventional BC Mixing Time (sec)	SMA Mixing Time (sec)	Remarks
Aggregates	20	20	As per IRC SP 79, Clause 5.3, mixing time should be increased by 5–10 seconds for uniform fiber dispersion. Additionally, wet mixing time should be increased by 5 seconds compared to conventional mixes.
Lime	2	3	
Fiber	–	5	
Bitumen	10	14	
Total	32	41	



- ❑ In the SMA mix, it's crucial that the fiber pellets we add open up to an optimal level within the mix before introducing the binder.
- ✓ To ensure this, the team conducted a multiple plant trial on dry mixing of the aggregate, and finalized total 41 sec for SMA production, including **5 sec** for fiber adding (**dry mix time**) and **14 sec** for bitumen adding and mixing (**wet mix time**).

3-Point Loading of Bituminous Mixes

- ❑ 3-point loading pattern in the bituminous mix production – to avoid segregation - uniform quality of the mix during transportation and site laying



- ✓ The Monitoring team trained the contractor team on the 3-point loading pattern to minimize mix segregation during site laying. Additionally, the HMP team was instructed on the proper procedure for loading the Bituminous mix onto trucks using this method..

Importance of Covering the Bituminous Mix Vehicle

- ❑ The contractor did not generally follow the practice of covering bituminous mix vehicles during transportation to the site.



- ✓ PMC team clearly informed the contractor team that failure to cover vehicles during mix transportation can lead to significant heat loss during transit, and potential hazards that may result in dangerous accidents.

Installation of Lime Silo of Appropriate Capacity

- ❑ Generally, the lime feeding process is being carried out manually during the operational phase of the Hot Mix Plant (HMP).



- ✓ It was suggested to install a lime storage silo to ensure uninterrupted production of the bituminous mix, by facilitating a continuous and controlled supply of lime to the mixing process.

Spilling of Lime from HMP Mixture Gate and Adjustments

- ❑ During the opening of the mixer discharge gate of the Hot Mix Plant (HMP), dry lime was observed discharging from the gate unintentionally.



- ✓ The PMC team identified lime spillage during the initial production phase due to a faulty mixer gate. The issue was resolved by **monitoring and fixing the gate's** closing mechanism.

Intelligent Compaction Check with NNDG (Non-Nuclear Density Gauge)

- ✓ As Stone Mastic Asphalt (SMA) mix tends to lose temperature rapidly, measures were taken to ensure that laying was carried out promptly to minimize heat loss. To support continuous paving and prevent paver stoppage, the number of tippers was increased to maintain a consistent supply of material



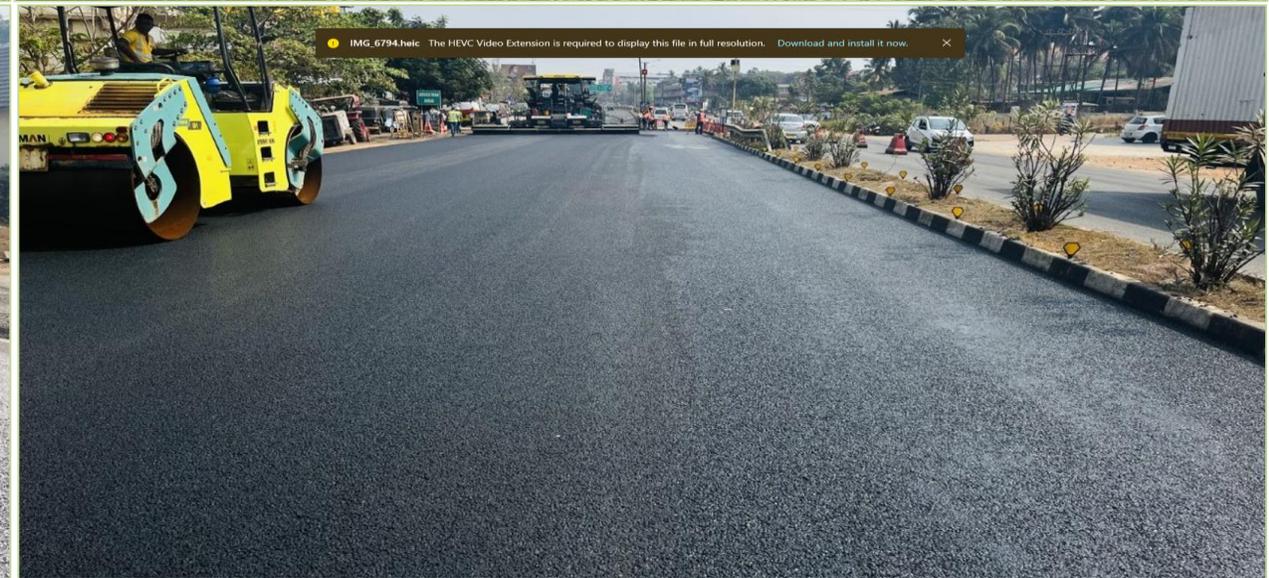
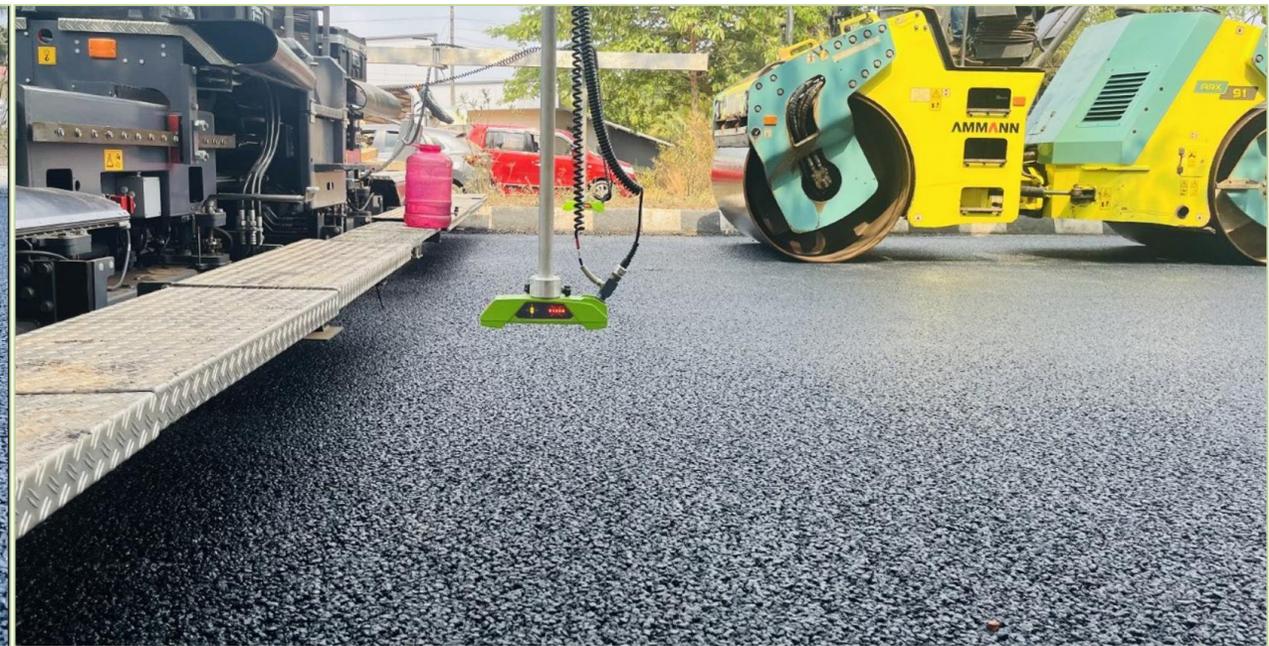
- ✓ To minimize the number of core cuts required for compaction testing on the SMA layer, it was discussed with the team to utilize the **Non-Nuclear Density Gauge (NNDG)** as an alternative method for assessing compaction levels. To optimize time and reduce unnecessary rolling, compaction data was recorded after each pass of the roller. This approach ensured that rolling was stopped once sufficient compaction was achieved, thereby saving both time and cost. Also, NNDG measurements were conducted at intervals of every 50–60 meters to ensure uniform compaction quality across the stretch.

Rolling Pattern Adjustments and Continuous Monitoring

- ✓ During the initial stage, rolling operations were observed to be conducted in an irregular manner, without adherence to a defined rolling pattern.



- ✓ The rolling pattern was revised to ensure that each pass included proper **one third drum overlap**, and compaction was completed prior to the cooling of the bituminous material, thereby enhancing overall pavement quality.



THANK YOU



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