Brihanmumbai Municipal Corporation

Thin Concrete Overlays For Roads

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Indian Concrete
Bengaluru Centre, Karnataka, 15th April 2023.

Indian Concrete Institute
(Mumbai Centre)

PRECAST TECHNOLOGIES
for Sustainable Construction

Date : 11th & 12th May 2023

Venue : VMCC Auditorium , IIT Bombay

About Indian Concrete Institute Mumbai Centre

ICI Mumbai Centre has conducted various conferences on trending topics and advancements in existing concrete technology. As the financial city of India, we have chosen a topic for the conference on sustainable construction adopting precast technology and precast products.

For Sponsorship , Exhibition Stall & Delegates Opportunities

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Contents

- Mumbai's Roads Department
- Introduction to Concrete Roads
- PQC requirements
- Construction of Concrete Road
- Bituminous Pavement Problems and its current practice
- Theory behind white topping
- Experimental Work
- Summary

Mumbai's Road Department

BMC HAS AN EXTENSIVE ROADS INFRASTRUCTURE IN MUMBAI

- The original island of Mumbai was only 24 km long and 4 km wide from Dongri to Malabar Hill (at its broadest point) and the other six were Colaba, Old Woman's island, Mahim, Parel, Worli,Mazgaon. Mumbai or Greater Mumbai today encompasses 436 sq km.
- BMC has about 1941 kms of roads infrastructure in Mumbai
- In addition, there are roads owned by PWD, MHADA, MPT and roads in private layouts
- Of the 1941 kms, approximately 990 kms are concrete roads

Activities . . . . . .

Road section

- Construction of D. P. roads
- Maintenance of major roads & roads having bus routes
- Widening of roads
- Improvement of footpath
- Improvement of roads by various methodologies
  - •Asphalting
  - •Mastification
  - •Concretization
  - •Interlocking paver blocks
  - •Thin and Ultra-Thin White Topping
- Running & maintaining Municipal asphalt plant for manufacturing and supplying asphalt mixes for emergency works
- Reinstatement of trenches, pothole repairs & spot repairs through agencies in the ward offices

Activities . . . . . .

Traffic section

- Prescribing Road line for existing roads
- Providing traffic amenities
  - Dividers
  - Lane marking
  - Traffic islands
  - Signals
  - Certain street furniture
- Implementation of pay & park scheme and approving parking layouts
- Co-ordination with various utility agencies and traffic police

APPOINTMENT OF STAC COMMITTEE

A Standing Technical Advisory Committee on Roads, consisting of eminent persons in the Field, under the Chairmanship of Shri N. V. Merani was constituted in September 2004 to suggest measures to improve construction & maintenance of Mumbai roads. Report submitted on 1st Jan 2005

SEVERAL CHANGES HAVE BEEN INCORPORATED IN CONTRACTS TO IMPROVE QUALITY OF ROADS IN MUMBAI

1 Integrated property-to-property development

- Carriageway
- Off-carriageway (e.g., footpaths and street furniture)
- Under carriageway (e.g., drains, utility ducts)

2 Integrated development and maintenance

- Three years for asphalt
- Five years for cement concrete

3 Detailed specifications laid down by experts

- Technical specifications
- Quality and maintenance manuals

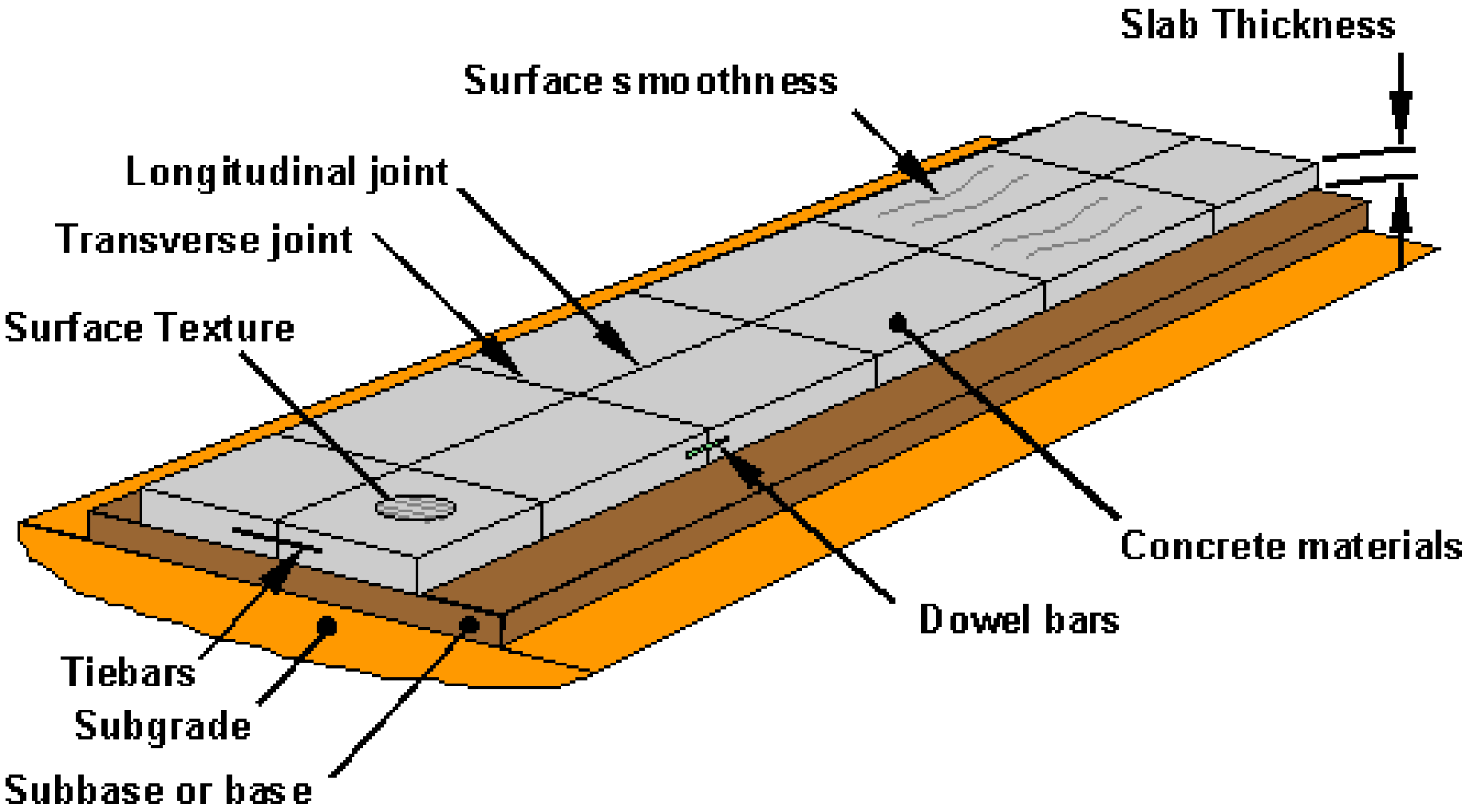
4 Modified vendor selection norms

- Specification of detailed technical criteria

Types of Rigid Pavements

- Jointed Plain Concrete Pavement (JPCP)
  - No temperature steel
- Jointed Reinforced Concrete Pavement (JRCP)
  - Temperature steel placed at mid height and discontinued at the joints
- Continuously Reinforced Concrete Pavement (CRCP)
  - Not popular in India – very costly
- Prestressed Concrete Pavement (PCP)
  - Not popular

Concrete Pavement - Basic Components



PQC REQUIREMENTS

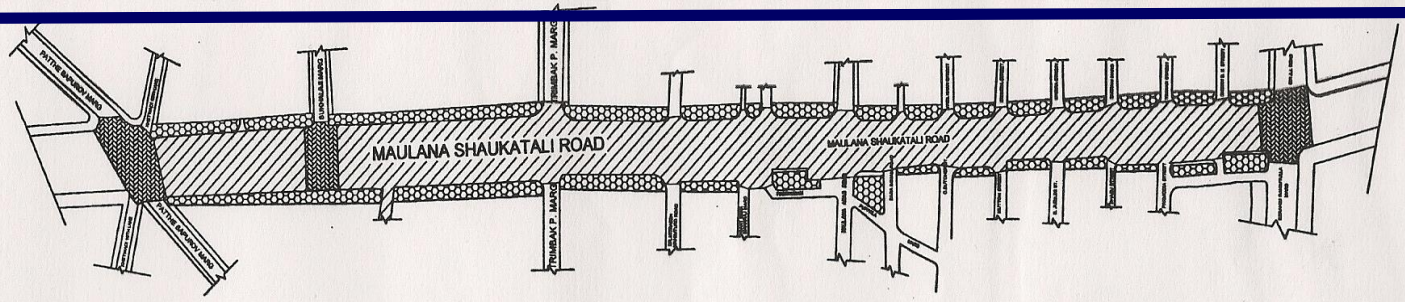
- Concrete Flexural Strength: 4- 4.5 N/mm^2
  (M40 Grade)
- Slump: 20-25 mm(paver), 40-50 mm(manual)
- Cement content: 425 kg/m^3 max.
- Use of superplasticisers
- Use of Fly ash & Micro-Silica

Why Concrete Roads in Mumbai ?

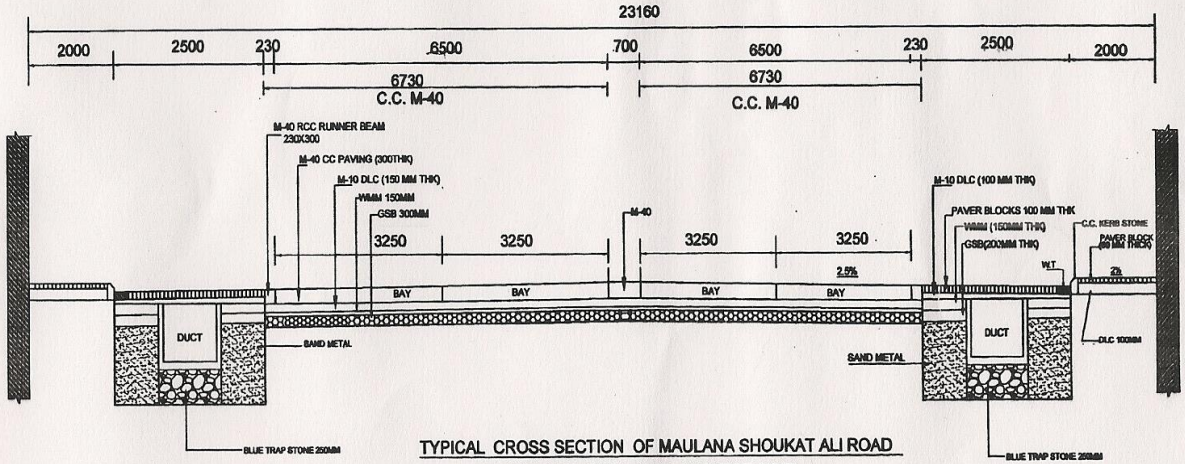
- Geographically Mumbai is reclamation of seven islands
- Mumbai receives rainfall of about 2500 mm every year
- Water table in Mumbai is high because of vicinity of sea
- Geological, Topographic limitations coupled with old development affecting surface run-off
- Heavy intensity of Traffic and axle loads
- Asphalt roads can not sustain due to above reasons
- A comprehensive program for concreting of major roads in Mumbai was taken up since 1989.
- Till date, 990 Km of roads in Mumbai are concretized

Typical cross section of Concrete Pavement

DY.CH.E.(ROADS) CITY/616/½
21/01/2009
C-242



MAULANA SHAUKAT ALI ROAD



TYPICAL CROSS SECTION OF MAULANA SHOUKAT ALI ROAD
AT MAULANA AZAD ROAD JN.(WEST SIDE)

(NOT TO SCALE)

N

NOT TO SCALE

NOTES:-

- PROPOSED C.C ROAD WORK
- PROPOSED FOOT PATH WORK
- EXISTING PAVER BLOCKS.

M. C. G. M			
CONCRETISATION OF MAULANA SHAUKATALI ROAD FROM PATTHE BAPURAO MARG JUNCTION TO IBRAHIM RAHIMTULLA MARG JUNCTION IN 'C' & 'D' WARD. (C-242)			
DRG. NO– DY.CH.E.(ROADS) CITY/616/½ /21/01/2009.			
S.E.R.C.–I	A.E.R.C.–I	E.E.R.C.–I	DY.CH.E.(RDS)CITY

Details of concrete crust

- Grade of PQC – M40
- Thickness-300 mm
- Width of bay-3.5 m
- Contraction joint at every 4.5 m
- 32 mm Dowels bars at every 300 mm centre to centre
- 12 mm dia Tie bars placed at every 450 mm
- Curing of concrete pavement by Chemical curing /impounding water

Pre-requisites for laying a good quality Concrete Pavement

Related to Concrete Production

- Batching and Mixing is carried out in approved batch mixing plant.
- The temperature of concrete at the time of placing shall not be more than 30° c.
- Chilled water to be used to bring down the temperature while manufacturing concrete.
- The mix is transported in R.M.C. transit mixers.

Pre-requisites for laying a good quality Concrete Pavement

Related to Concrete Post Placement

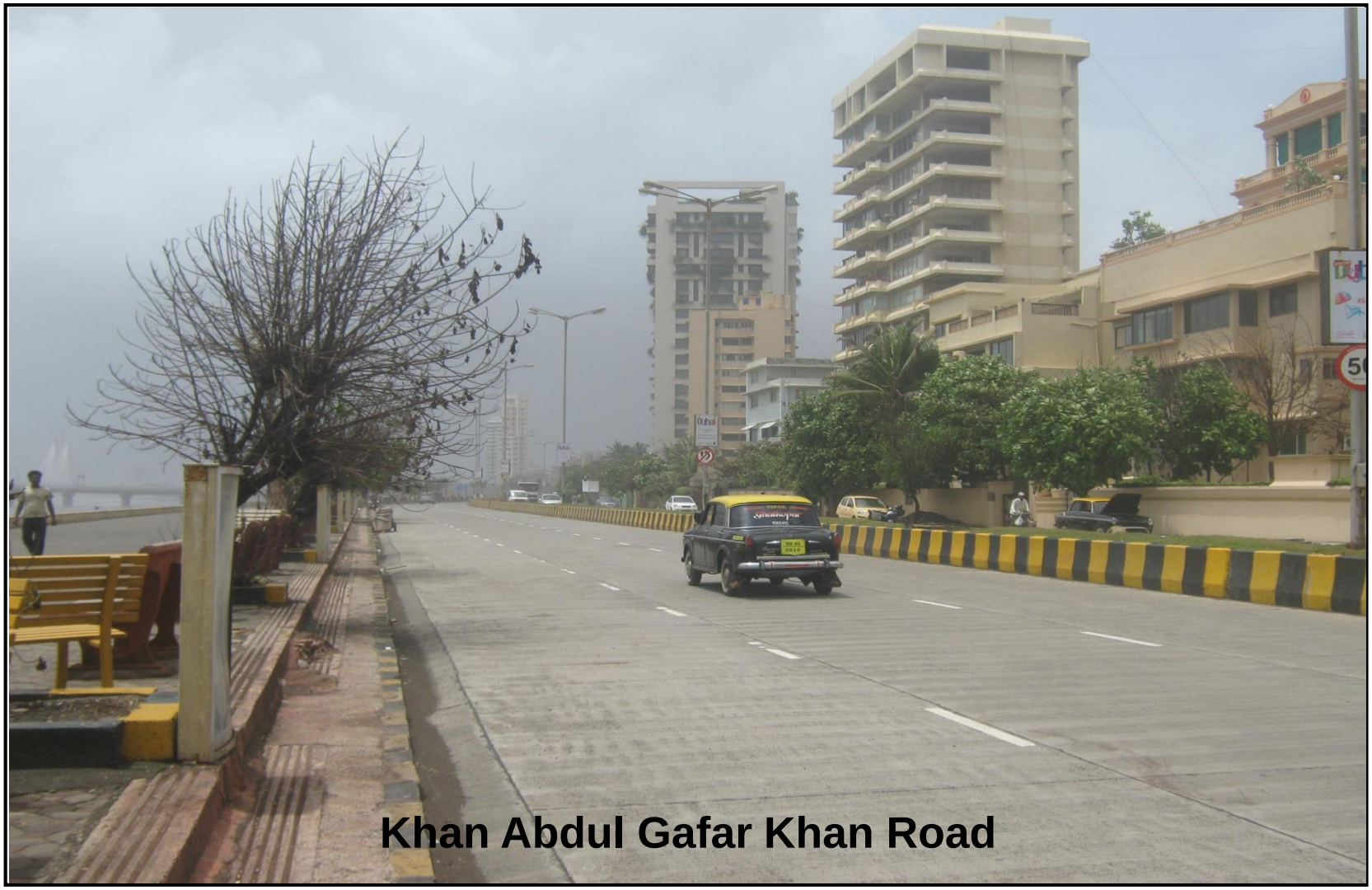
- Covering concrete surface with wet burlap immediately after texturing & application of curing compound.
- Protection of concrete surface from sun & strong winds.
- Joint cutting at the right time.
- Effective curing – membrane & wet curing.

Advantages of Concrete Roads

- Long Life (about 25-30 years)
- Very low maintenance cost
- Lower life cycle cost
- Impenetrability to water
- Pothole free riding
- More reflectivity of surface

View of Concrete pavement in Mumbai

View of Concrete pavement in Mumbai



View of Concrete pavement in Mumbai

J.K. Kapur Chowk

Contents

- Bituminous Pavement Problems and its current practice
- Theory behind white topping
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Municipal Corporation Of Greater Mumbai

Using New Technologies & Improved Methods in Road Construction

BITUMINOUS PAVEMENTS: Problems

Require repeated maintenance

Distress in early service life

- Rutting,
- Cracking,
- Settlement
- Pot holes

Expensive if service life cost is considered

Reasons for Distress

- Improper sub-grade
- Improper surface and sub-surface drainage
- Leakages in underground water mains and wet utilities
- Water Logging
- Increase in traffic density and axle loads
- Frequent cuts on road pavements for Utilities

BITUMINOUS PAVEMENTS : UPGRADATION

- Current Practice
  - Patch repairs with bitumen
  - Occasional upgradation with a Bitumen overlay
  - Results : deterioration unabated
- Is there an alternative?
  - Which is
    - Durable
    - Cost-effective
    - Technically superior

Theory BehindWhite topping

- What is White topping?
  - WHITETOPPING is defined as a Portland Cement concrete(PCC) overlay constructed on top of an existing bituminous pavement.
  - It is new and viable rehabilitation alternative to improve the structural capacity of existing pavement.
  - Usual White topping thickness >200 mm.
  - Studies indicates good to excellent performance.

Types of white Topping

1.Convention white topping

2.Thine white topping

3.Ultra thin white topping

White Topping,Thin White topping & UltraThin Whitetopping

What is TWT and UTW ?

➢Thin Whitetopping (TWT)

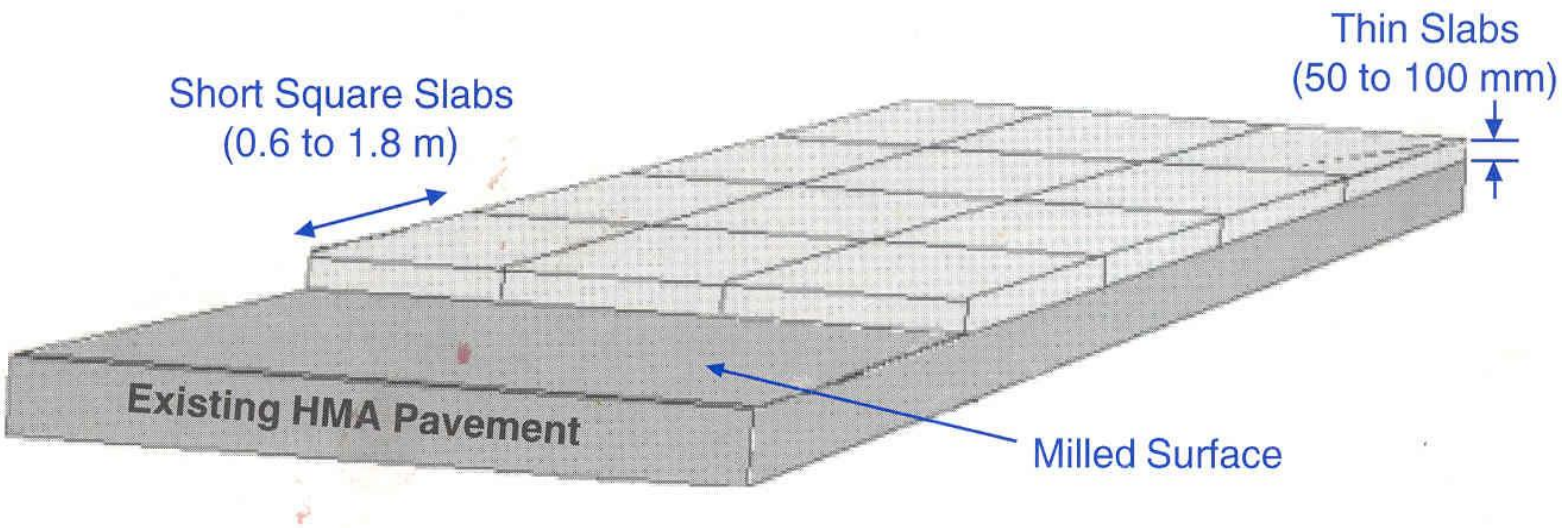
Pavement thickness – 100-200mm
In most cases, designed and constructed without consideration of bond between HMA and concrete

➢Ultra-Thin Whitetopping (UTW)

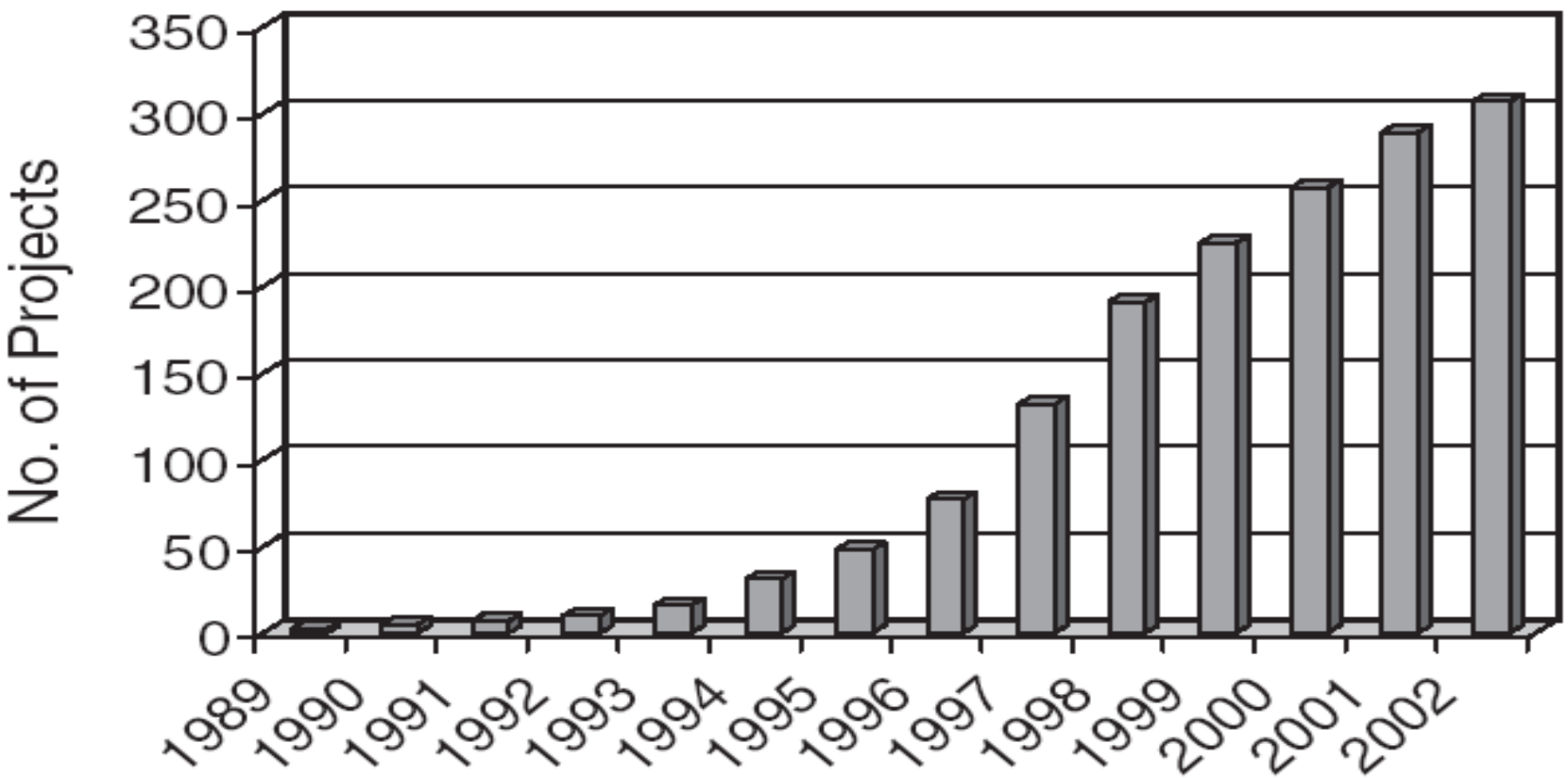
Pavement thickness < 100mm
designed and constructed with consideration of bond between HMA and concrete
Closer joint spacing

Typical c/s of TWT

support to the UTW overlay (ACPA 1998).



Typical c/s of UTWT



ADVANTAGES OF UTWT

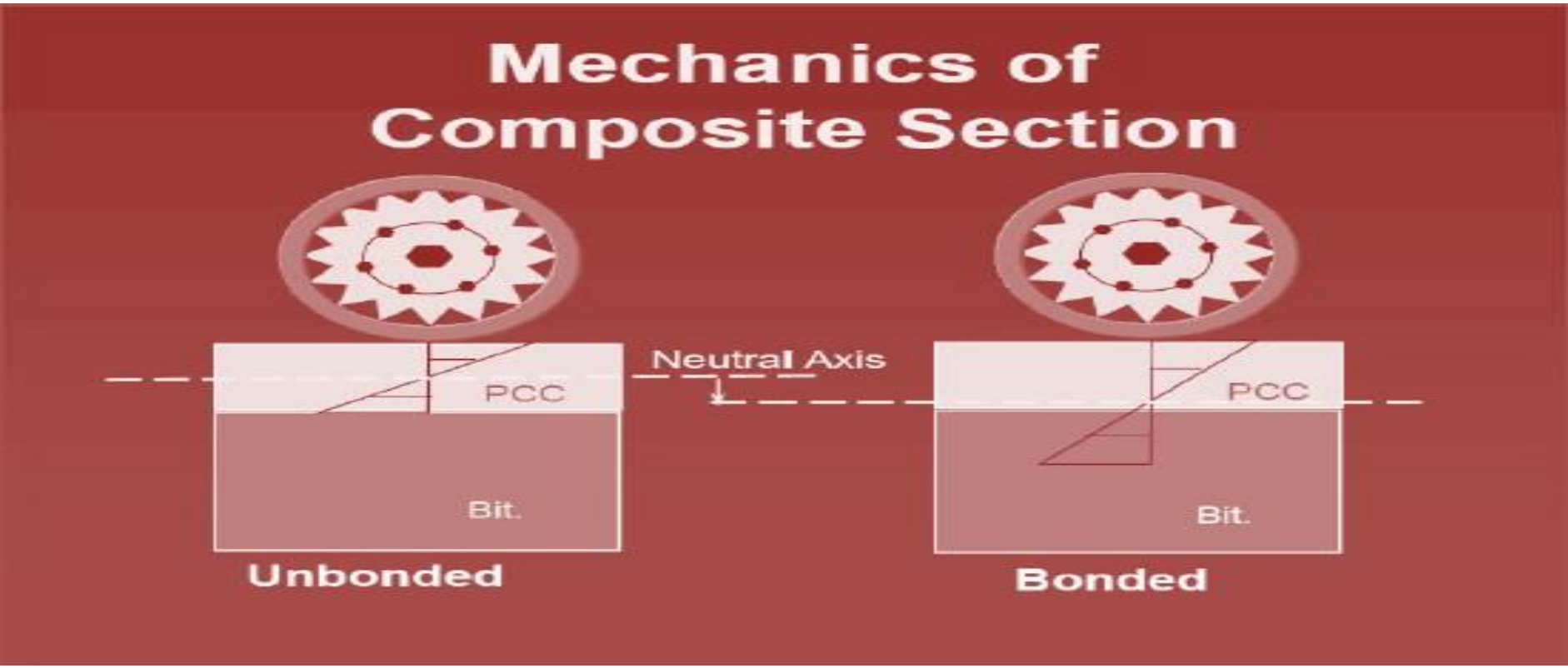
- Reduced thickness
- Fast-Track construction
- Reduced maintenance
- Cost-Effective compared to asphalt overlays
- Improved service life
- Little pre-overlay repairs
- Improvement in safety in view of the increased reflection of light
- Improving the environmental benefits

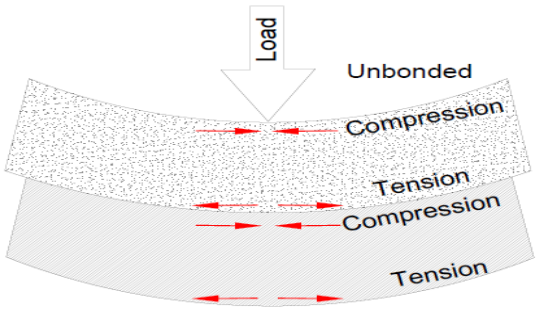
Necessity of Sound Bond

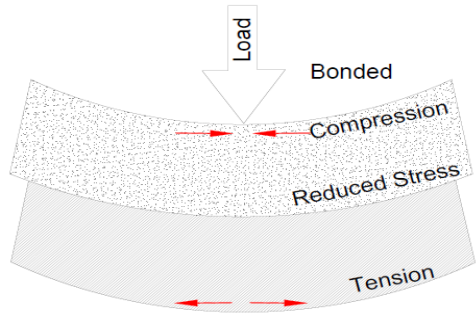
UTW overlays are designed & constructed with assumption of sound bond between plan concrete and HMA material

Ensures composite action between Asphalt and Concrete

Stresses in the top concrete layer are low in view of the composite action







- In case of bonded system due to composite action between concrete and flexible layer, neutral axis shifts downward with the result that much of the area of PCC slab comes under compression

Characterization of HMA

Adequate characterization of HMA highly essential for UTW

Visual Inspection

Lab. and field Tests

- - The Hamburg wheel track test
- - Dynamic Modulus test
- - Falling weight deflectometer

Concrete mixes for TWT : Main Parameters

- Fast-Track type construction
  - ✓ One day Flexural strength: 4 MPa
  - ✓ One day Compressive Strength : 35MPa
- Mix requirements
  - ✓ Mineral admixtures
  - ✓ Silica fumes
  - ✓ Fly-ash/a combination of two
  - ✓ Tyre rubber aggregate
  - ✓ Low water/binder ratio
  - ✓ Use of a Superplaticiser
  - ✓ Polypropelene fibres

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Rubber Aggregates used in Concrete Mix

Mixing of ingredients

No Segregation

Homogeneous Mix

After cube test

Thin Concrete Overlays for Roads

Ingredients	VTMS07	VTMF02	VTOF02	VTMS08P	VTMF03P	VTOF03P
Cement, kg	450	380	420	450	380	420
Micro-silica, kg	35	30	0	35	30	0
Fly-ash, kg	0	100	105	0	100	105
Total Binder	485	510	525	485	510	525
Polypropelenefibres, kg	0	0	0	0.900	0.900	0.900
Aggregate, kg: 20 mm	633	607	601	644	639	622
Aggregate, kg: 10 mm	422	405	400	430	426	415
Vaitarna sand	497	497	491	486	463	470
Curser Dust	332	331	328	324	309	313
Water, lit	121	143	147	121	143	147
HRWRA, lit	9.70	5.30	5.25	9.70	6.63	6.56
	2.00%	1.04%	0.7%	2.25%	1.30%	1.25%
W/B Ratio	0.25	0.28	0.28	0.25	0.28	0.28
Slump (mm)	65	80	80	55	60	75
Comp Strength, MPa						
1 Day	35.11	19.73	19.87	36.31	24.8	26.8
3 Days	51.47	32.18	34.89	54.84	38.44	37.95
7 Days	69.02	45.51	47.78	68.71	56.31	48.71
28 Days	94.30	69.07	69.56	90.42	72.26	70.44
Flexural Strength, MPa						
1 Day	3.6	-	-	4.00	-	-
3 Days	-	4.20	4.00	-	4.20	4.2
7 Days	6.80	4.40	4.40	7.00	5.60	4.6 (6D)

Construction of Thin White Topping

Construction Methodology

- **Pre-overlay repair**
  - Creation of uniform support to concrete pavement essential
  - Repair of cracks, shoving, leveling
  - Milling creates better bond with HMA
  - Min. HMA thickness 75 mm

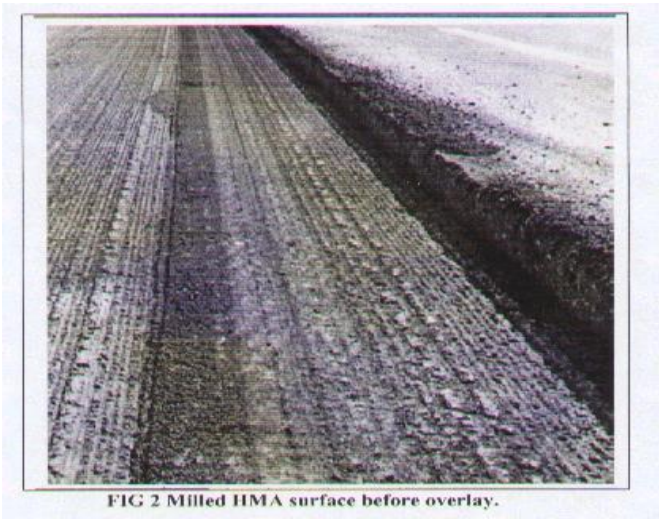
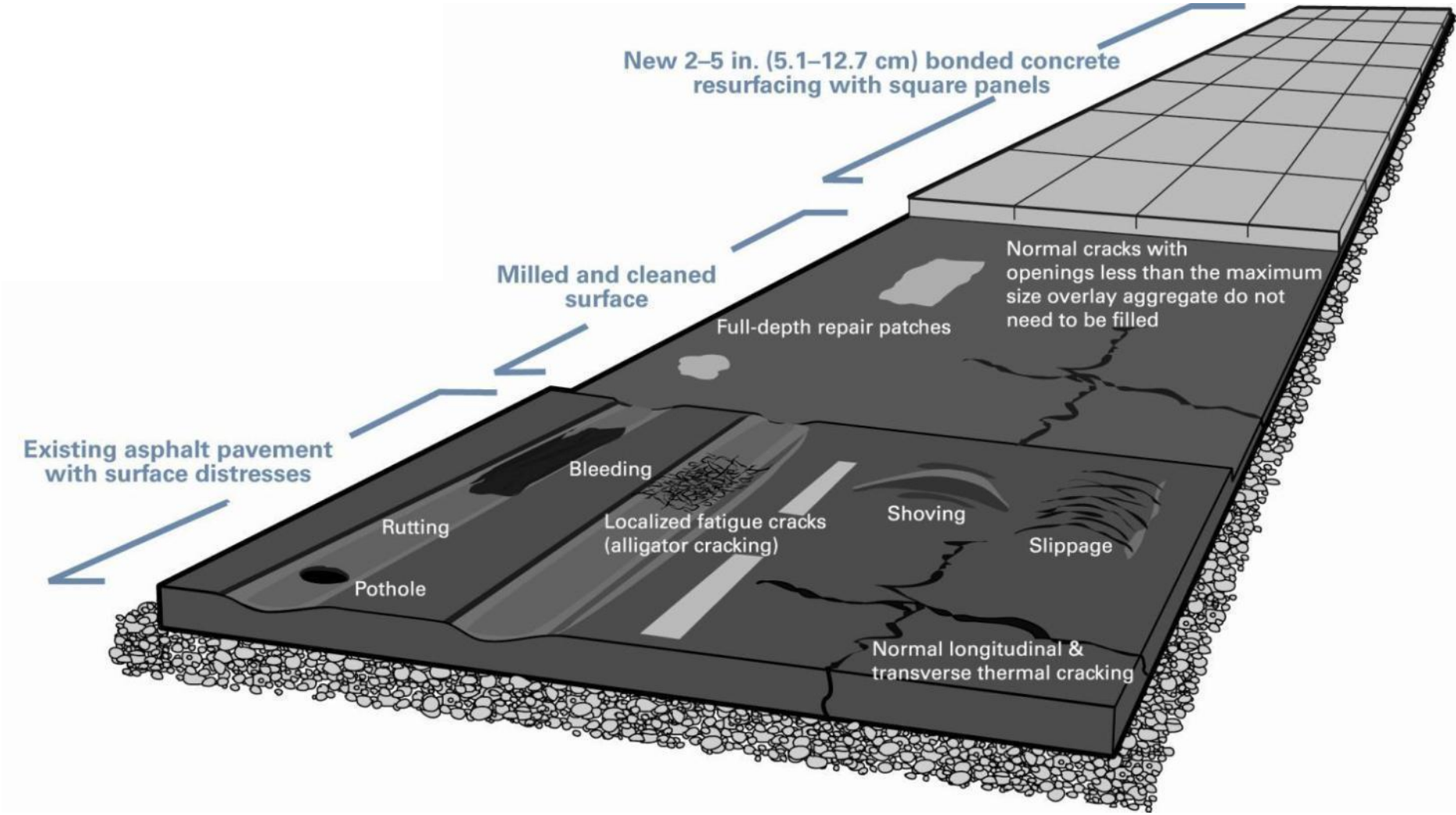
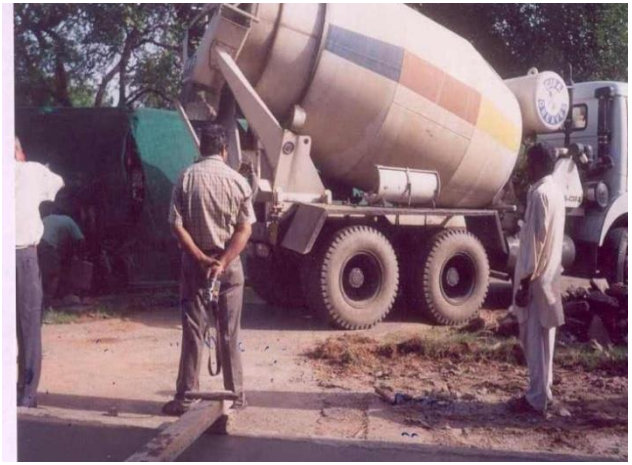


FIG 2 Milled HMA surface before overlay.



- Spots of distress that aren't visible can be determined through evaluation
- Localized areas of weakness can be strengthen through patching. Milling can remove

Construction Methodology..



➢ Concrete production

➢ Proper Placing, vibrating

➢ Adequate Curing

Joints in UTW

Usual spacing : 12 to 15 times thickness (0.6 to1.8 m)

Shorter spacing reduces curling stresses

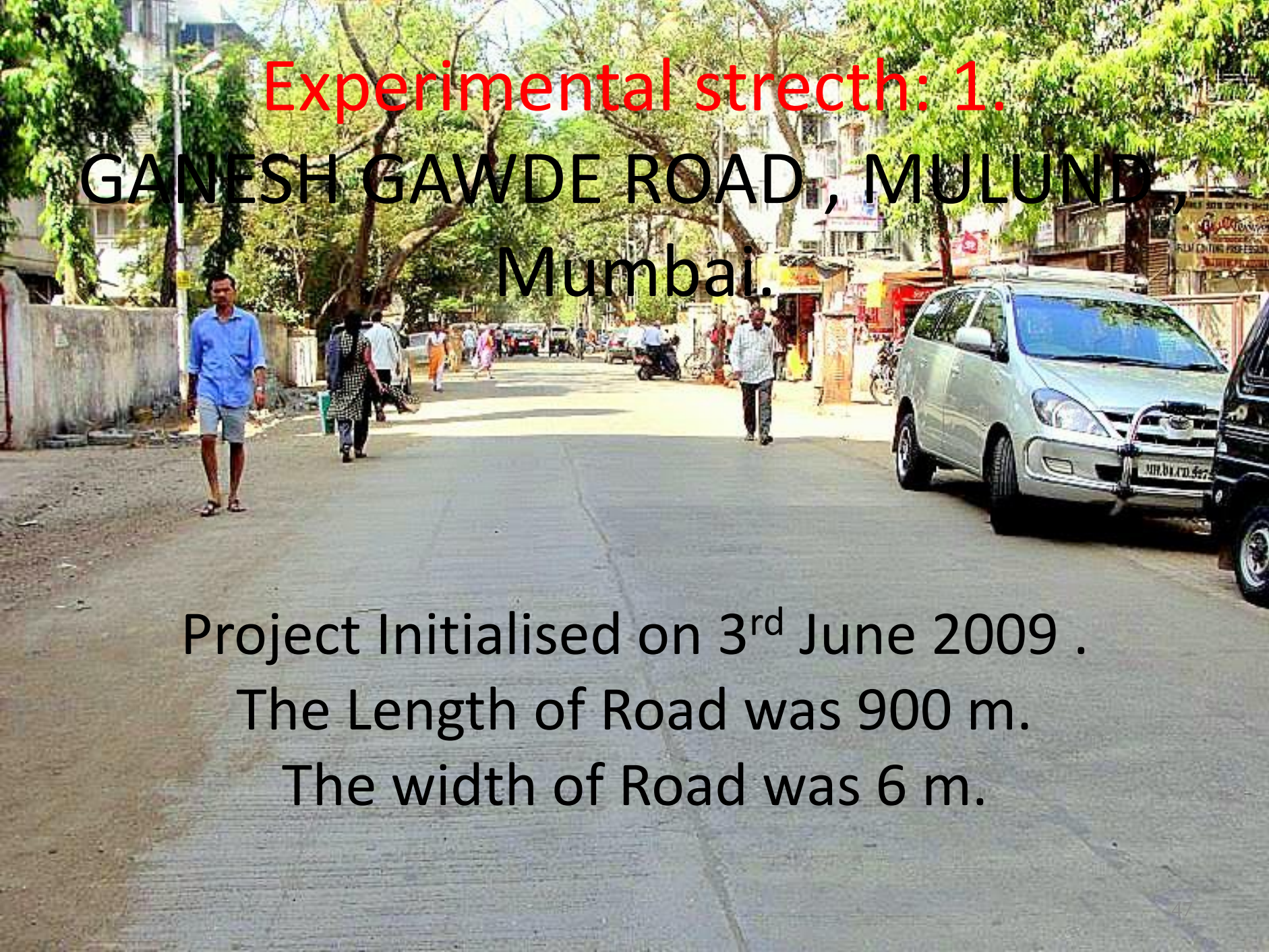
Early Joint cutting essential

Can use “early entry” saws

Cost Comparison

For 1 km (Two Lane including SWD)

	Cement Concrete	Asphalt Concrete	Thin White Topping
Area	7000	7000	7000
Cost per Sq.Mt	3931	2450	2603
Total Cost	27,517,000	17,150,000	18,221,000
SWD Cost	23150	23150	23150
	46300000	46300000	46300000
	73,817,000.00	63,450,000	64,521,000
	Rs.7.50 Cr.	Rs.6.35 Cr.	Rs.6.45 Cr.



Experimental strecth: 1.

GANESH GAWDE ROAD , MULUND , Mumbai.

Project Initialised on 3rd June 2009 .

The Length of Road was 900 m.

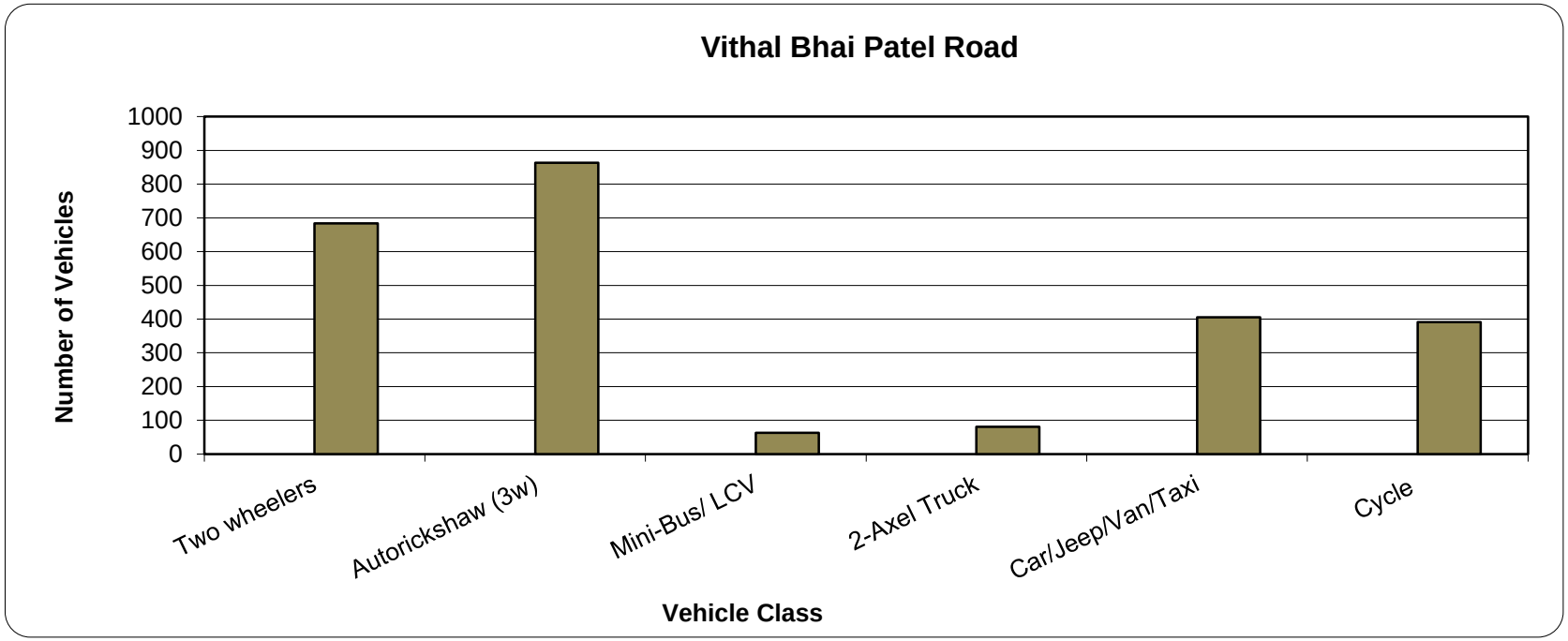
The width of Road was 6 m.

Design of TWT

- Design Method
  - ✓ Developed by the PCA, USA
  - ✓ IRC SP:76-2008
- Thickness of TWT determined by:
  - ✓ Type & Volume of existing and expected traffic
  - ✓ Strength & Condition of existing pavement
  - ✓ Material properties of the concrete

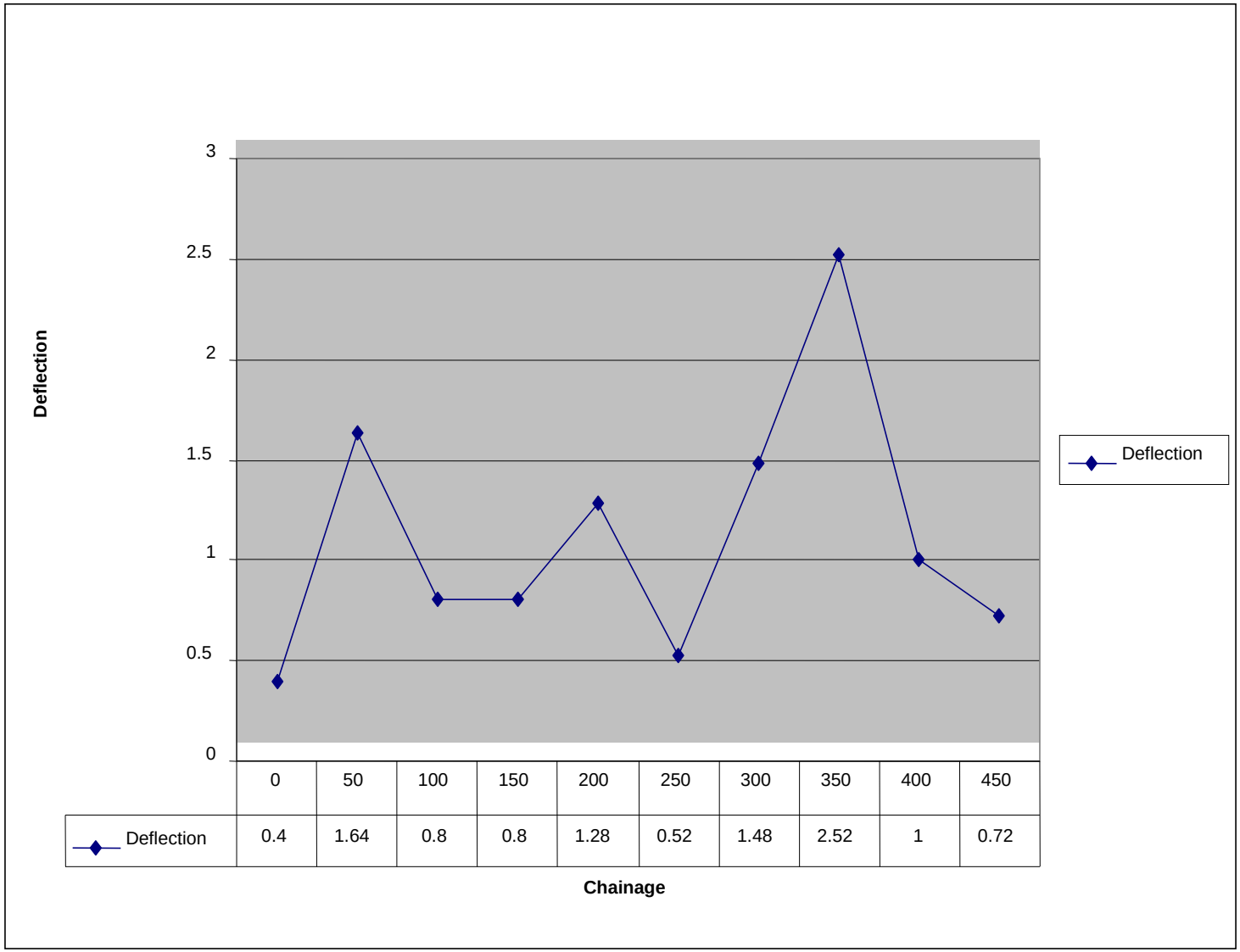
Traffic Data on VithalBhai Patel Road

➢ Three days twenty hours classified traffic count was conducted on the proposed road to estimate the daily average traffic flow. For the purpose of design, only number of commercial vehicles has been considered as per IRC: 81-1977



BBD Test

Benkelman Beam Deflection curve



	0	50	100	150	200	250	300	350	400	450
Deflection	0.4	1.64	0.8	0.8	1.28	0.52	1.48	2.52	1	0.72

EXPERIMENTAL RESULTS

Workability of fresh concrete (Slump test)

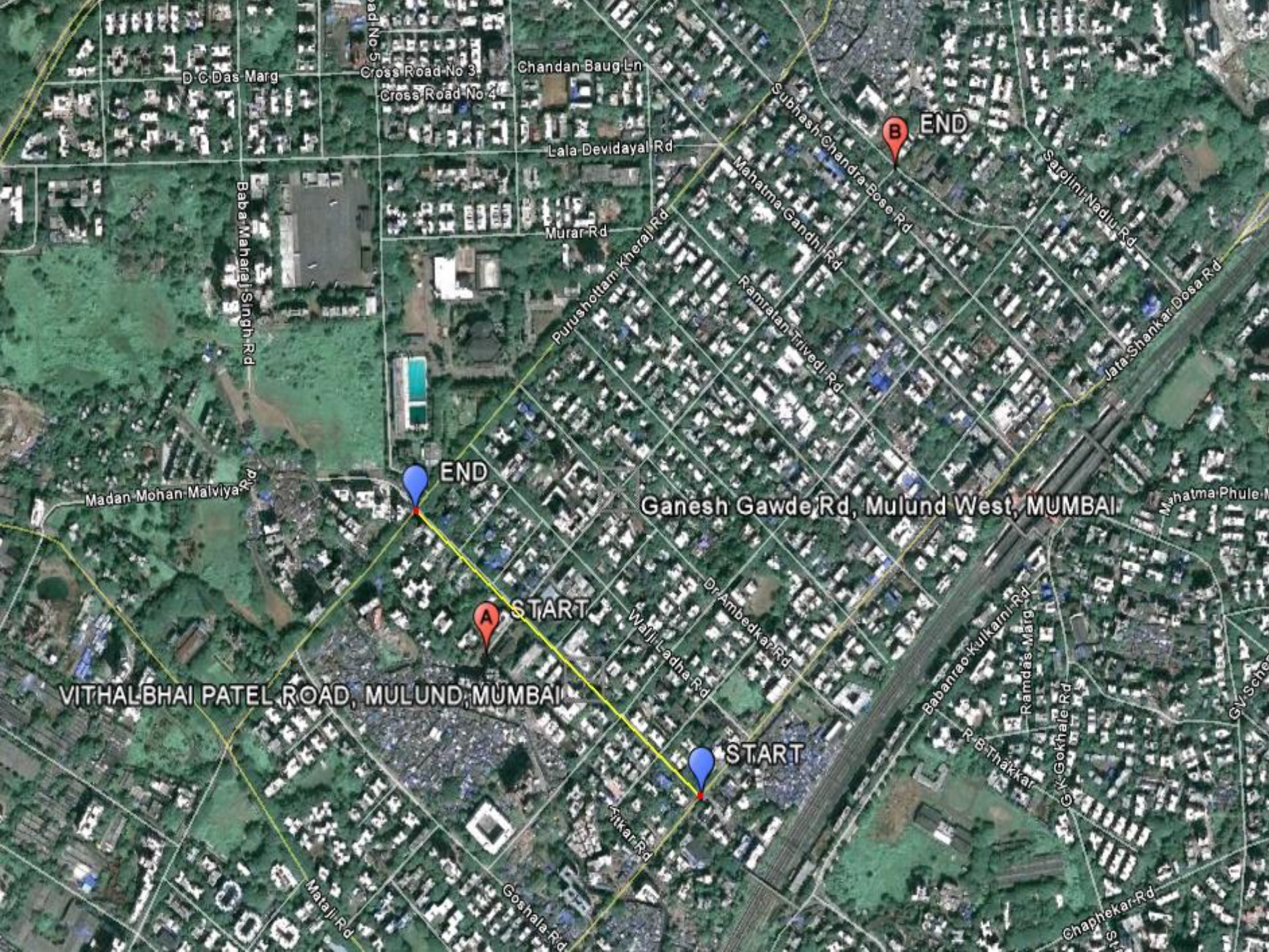
FLEXURE TESTED SPECIMEN

Field Flexural and Compressive strength at V.P Road

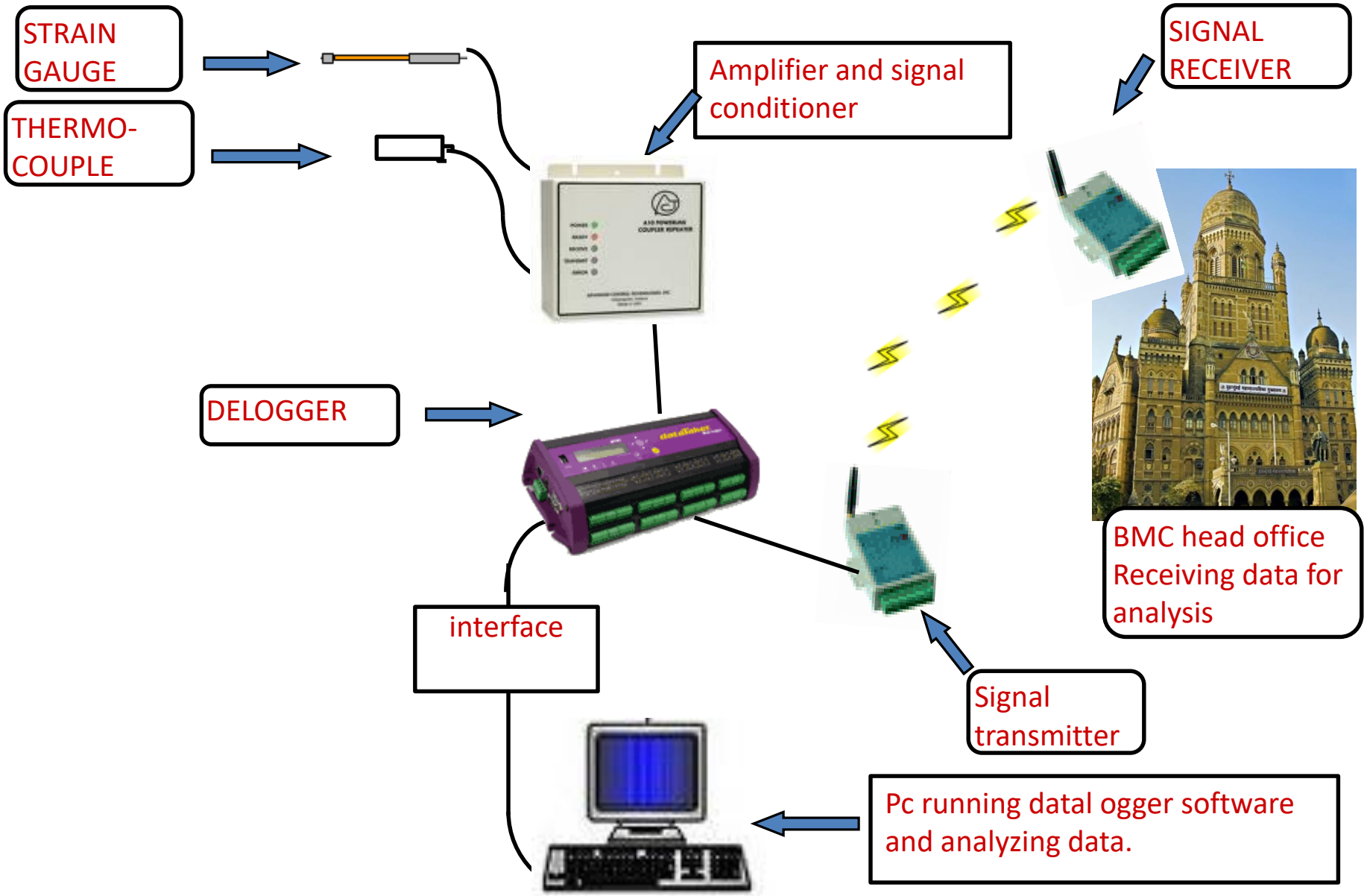
As a part of quality control, the actual compressive and flexural strength of concrete received at the site during construction of the experimental stretch at Vithalbhai Patel Road in Mulund, Mumbai

Sr No	Date of Casting	7 Days Testing	
		Flexural Strength	Compressive Strength
1	1/13/2010	7.02	66.22
2	1/15/2010	6.96	67.91
3	1/21/2010	6.99	66.73
4	1/29/2010	6.99	65.73
5	1/30/2010	7.26	66.58
6	2/2/2010	6.99	66.27
7	2/9/2010	6.99	66.93
8	2/10/2010	6.93	66.37
9	2/11/2010	6.96	67.91
10	2/13/2010	7.08	66.36
11	2/16/2010	6.84	65.42
12	2/18/2010	6.99	66.74
13	2/20/2010	7.08	66.92
14	2/25/2010	6.93	65.35
15	3/3/2010	7.02	66.22
16	3/9/2010	7.23	65.75
17	3/12/2010	7.03	66.22
18	3/17/2010	7.14	65.11
19	3/19/2010	7.07	66.73

Instrumentation for Thin White Topping


B
END
Subhash Chandra Bose Rd
Sarojini Nadiu Rd
Mahatma Gandhi Rd
Ramratan Trivedi Rd
Purushottam Kheraj Rd
Jata Shankar Dosa Rd
Lala Devidayal Rd
Murar Rd
Baba Maharaj Singh Rd
D C Das Marg
Cross Road No 3
Cross Road No 4
Chandan Baug Ln
END
Madan Mohan Malviya Rd
Ganesh Gawde Rd, Mulund West, MUMBAI
A
START
Dr Ambedkar Rd
Wafji Ladha Rd
VITHALBHAI PATEL ROAD, MULUND, MUMBAI
START
Babanrao Kulkarni Rd
Ramdas Marg
R B Thakkar
G K Gokhale Rd
Tikar Rd
Mataji Rd
Goshala Rd
Chaphekar Rd

Name of Road:Vittalbhai Patel



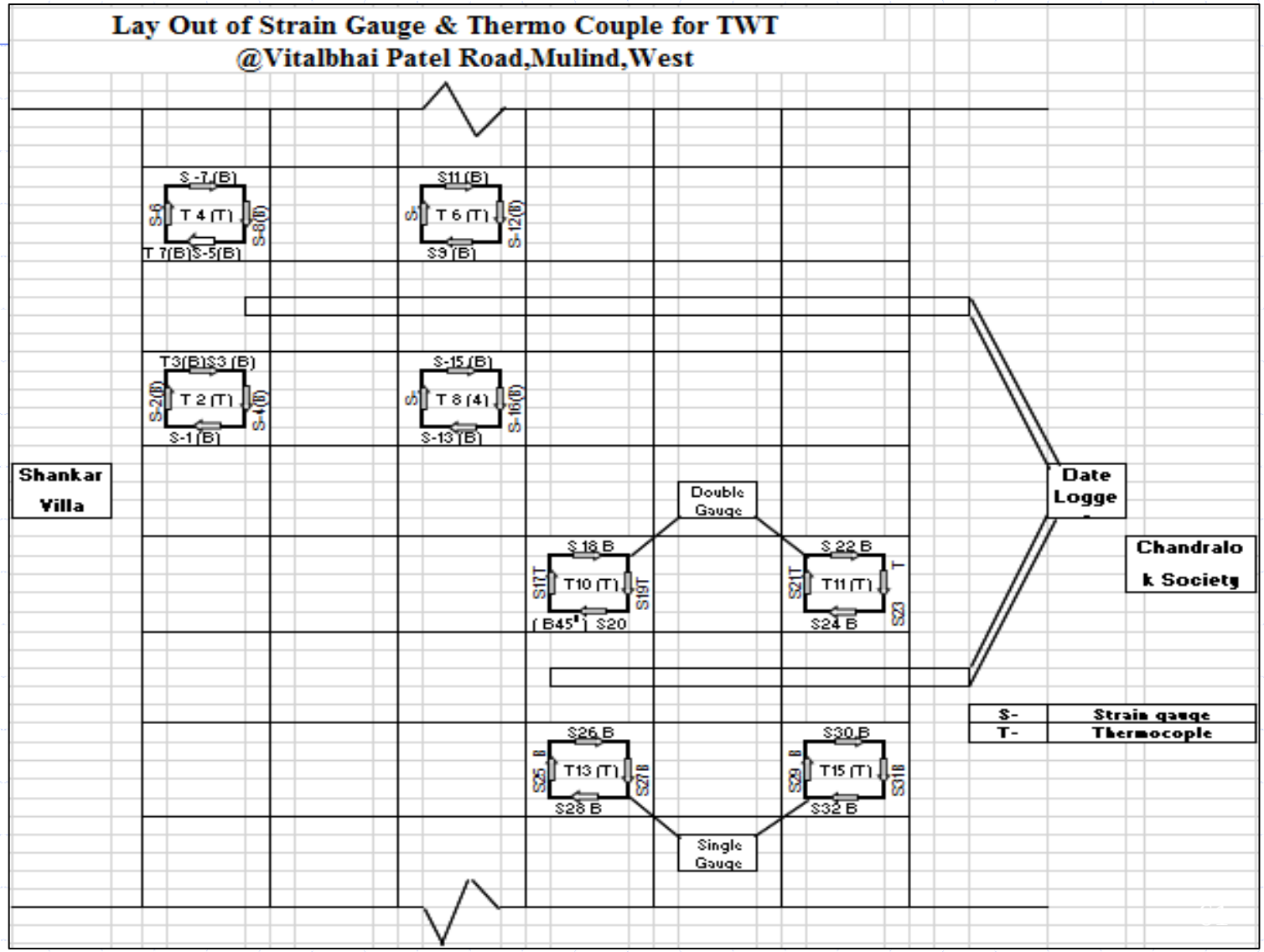
SCHEMATIC DIAGRAM OF DATA PROCESSING

Strain Gauge

Arrangement of sensors

- A strain gauges and thermocouples were tied to a square bar
- The square bar was kept at different locations
- Concrete was allowed to pour and physical compaction was done.
- The cables were allowed to passed through G.I paper to the data logger

Schematic Diagram of Sensors



Arrangement of sensors

Pouring of concrete on sensors

Pouring of RMC Concrete

- From the laboratory trials a Mix VTOFO3 was used for construction of TWT at V.P. Road
- The concrete was brought from transit mixer
- As the width of road is 6.0m, 3.0m lane was used for placing of concrete and remaining 3.0m used for traffic flow
- The concrete was placed manually

Vibrating by plate and screed Vibrator

- After placing of concrete 60 mm needle vibrator was used followed with plate vibrator
- Finally single skid vibrator was used for levelling the concrete at the top and releasing the entrapped air

Finishing of Thin white topping

Surface Texturing of TWT

Chemical Curing of TWT

- In order to maintain the moisture content in concrete Chemical curing is done immediately after finishing of concrete

Joint Cutting of TWT

- The process of cutting was done after 5 hours of chemical curing
- If the curing is not done on specific time there is a possibility of transvers cracks on the concrete surface
- The joints were cut 1 m x 1 m in transvers and longitudinal directions and a thermocool sheet was inserted in joints to protect breaking and filling of joints with dust and other materials

Pond Curing of TWT

- Pond curing was done for seven days
- Joints were cleaned and filled with polysulfide material
- TWT was opened for traffic

Finished surface of TWT at V.P Road after 14 years


A View of Ultra-Thin White Topping (R.C.Rd.2006)

Ganesh Gawade Road Mumbai

Vithal bhai Patel Road, Mumbai

Analysis and Performance Evaluation Studies for Thin White Topping

Recommended Temperature Differentials In Celcius For Concrete Slabs

Zone	States	Thickness of pavement			
		150 mm	200 mm	250 mm	300mm and higher
1.	Punjab, UP, Uttaranchal, , Rajasthan, Haryana and North M.P, excluding hilly regions	12.5	13.1	14.3	15.8
2.	Bihar, Jharkhand, West Bengal, Assam and , excluding hilly regions and coastal areas	15.6	16.4	16.6	16.8
3.	Maharasthra, Karnataka, South M.P., Chattisgarh, Andhra Pradesh, and North Tamil Nadu, excluding hilly regions and coastal areas	17.3	19.0	20.3	21.0
4.	Kerala and South Tamil Nadu, excluding hilly regions and coastal areas	15.0	16.4	17.6	18.1
5	Coastal areas bounded by hills	14.6	15.8	16.2	17.0
6	Coastal areas unbounded by hills	15.5	17.0	19.0	19.2

Temperature differential for 150 mm thickness of TWT Slab

Sl.No	Thickness of Slab in mm	Maximum difference in temperature ,^{o}C							Average Temperature,^{o}C
		Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	
1	150	8.07	8.03	7.53	6.18	7.92	8.04	6.63	**7.49***

*IRC specifies average temperature of **14.6**^{o}C for 150mm thick slab

Non-Destructive Testing

Durability Test: The following test was carried on TWT pavement at V.P. road

- Water Permeability Test
- Rapid Chloride Permeability Test (RCPT)

NDT in Process


Core Cutting Machine


Core Cutting in process


After Core Cutting


Core Cutting Sample

Test results of Water Permeability

ID Mark	Type of Specimen	Specimen size(mm)	Weight (Kg)	Depth of water Penetration (mm)	
				Low	High
VP Road	Concrete Cylinder	145 x 130	5.188	Nil	Nil

Durability Tests


Ground Penetrating Radar


RCPT Test


Air Permeability Test

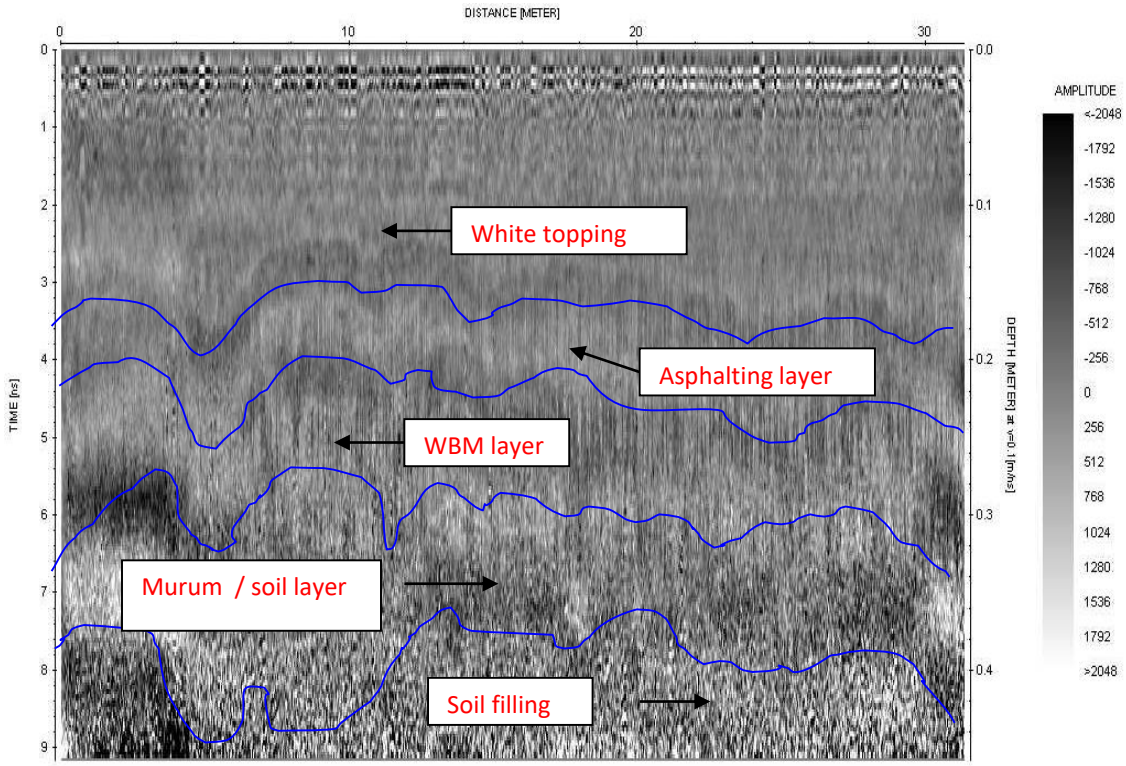

RCPT Test

Air Permeability test

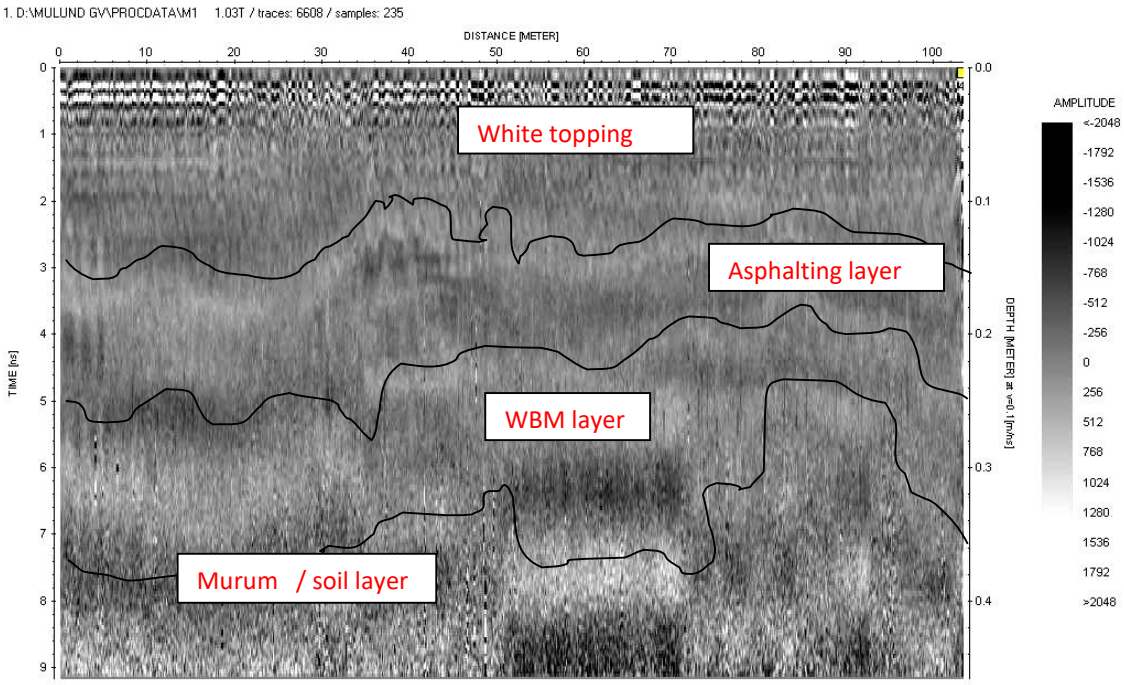
Description	Type of Test	Result	Autoclam Air Permeability Index Ln(Pressure)/min	Protective Quality
Concrete pavement with Thin white topping	AIR PERMEABILITY, Ln (Pressure)/min	0.31	<= 0.10	Very Good
			>0.1 <=0.50	Good
			>0.5<=0.9	Poor
			>0.9	Very Poor


Controller
Data logger
Antenna
Encoder wheel

Scanned Images of TWT at V.P.Road



Scanned Images continued…



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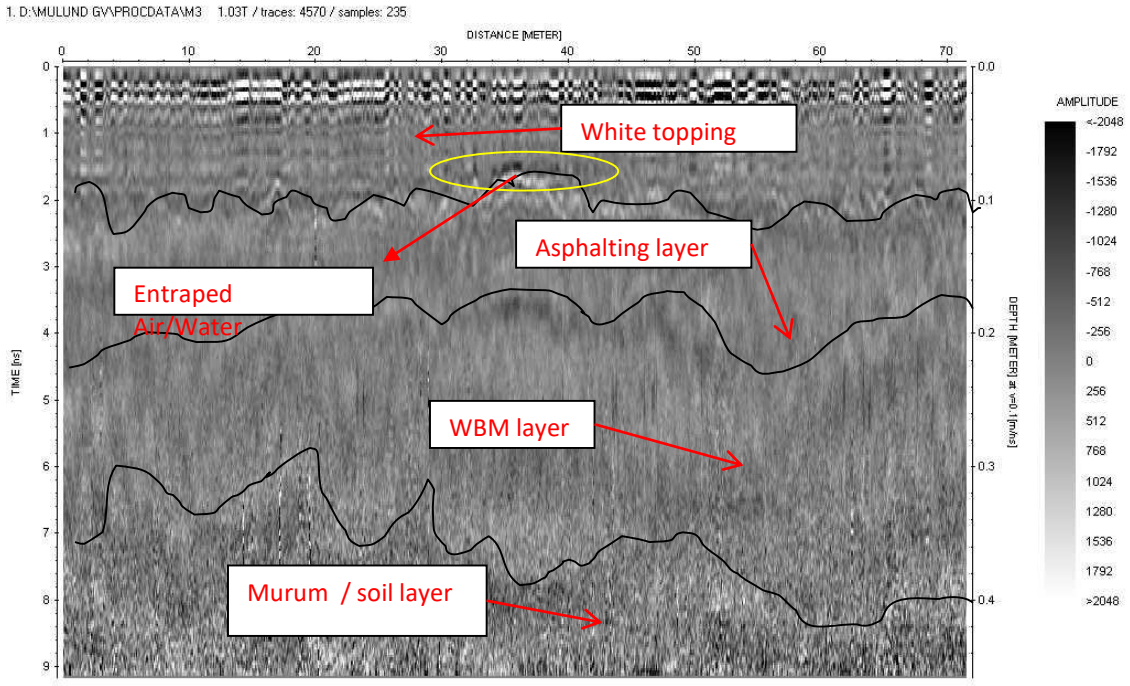

Conclusions

CONCLUSIONS

- Thin White-Topping pavement overlay can be advantageously carried out over existing bituminous pavements resulting in road pavements with prolonged service life with negligible maintenance interventions for even medium to moderately heavy traffic

- The concrete mix with 20% ASTM type F fly ash and appropriate quantity of polypropylene fibers and superplasticizer achieved a flexural strength of 4 MPa at the end of three days. Such mixes can be efficiently used for opening the TWT overlaid road within a week's time to traffic

CONCLUSIONS…

- By replacing 10% of rubber aggregate with natural aggregates results in huge saving of natural aggregate with good compressive strength
- The results of Durability tests carried out are within the permissible limit
- A wireless technology was used to record the sensors data, these saved time and man power
- The maximum TWT pavement temperature has been found to be only 10% more than the maximum ambient temperature. This prompts for separate guidelines relating to temperature stresses for concrete roads in built-up areas with high rises and trees on both sides

CONCLUSIONS…

- The temperature measurements revealed that the temperature gradient across the thin white topping is only one half the value suggested by IRC:58 (2011)
- Based on this isolated study it cannot be generalized, in view of this observation it may be inferred that the temperature differentials that are used in the design are on the highly conservative side
- The Ground Penetrating Radar (GPR) scanning revealed that there is a perfect bonding between asphalt and concrete
- Even after more than 8 years no distress or settlement is seen on TWT

Let's all join hands to build a better tomorrow...

by constructing world class Durable Structures.....