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Development of Pavement Deterioration Models for Urban Roads

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Some Basic Definitions

- **Pavement performance:** Pavement performance is a measure of the in-service condition of the pavement. Performance is often expressed in two ways; the first is structural performance which is expressed in terms of distresses such as cracking etc., and the second is functional performance expressed in terms of serviceability, which in turn might be function of distresses such as rutting and roughness.
- **Pavement deterioration:** Represents a negative change in performance or condition of the pavement, i.e., an increase in distresses or decrease in serviceability.
- **Rutting:** Surface depression in the wheel path caused by combination of deformation in the pavement layers and studded tire wear.
- **Roughness**: Longitudinal unevenness in the wheel path.

Development of Pavement Deterioration Models for Urban Roads

Objectives of the Project

- Development of performance prediction models for urban roads under different traffic levels, duly considering the structural and functional condition of the pavements.
- Develop a GIS based database on inventory of the urban roads by considering both the structural and functional condition data.
- Calibrate and validate pavement deterioration models for urban roads.
- Prediction of future pavement condition under different maintenance strategies.
- Prioritize the rehabilitation and reconstruction works and develop a framework for the pavement management system for urban roads.

Arterial Roads in Bangalore City

Sl. No.	Stretch Code	Road Stretches	Road Length in Km	Category of Road	No. of Lanes	Combined LWP and RWP
1	**SB-NDH**	Hosur Road Junction Silk Board to Nayandanahally	11.7	Arterial/ORR	4	23.4
2	**SMF-KS**	Sumanahally flyover Junction to Kanteerava Studio gate	3.9	Arterial/ORR	4	7.8
3	**AIT-MRJ**	Dr AIT College gate to Magadi Road junction	3.1	Arterial/ORR	4	6.2
4	**KS-AIT**	Mysore Road junction (Kengeri Satellite town) to Dr AIT College Signal	5.5	Arterial ORR	4	11
5	**BEL-HBL**	BEL Circle to Hebbal Flyover signal	3.5	Arterial/ORR	4	7
6	**HBL-NV**	Hebbal Flyover signal to Nagavara Signal	2.6	Arterial/ORR	4	5.2
7	**SB-MHU**	Silk Board Junction till Marathahalli underpass	10	Arterial/ORR	4	20
				Total Road Length in Kms		**80.6**

Sub- Arterial Roads in Bangalore City

Sl. No.	Stretch Code	Road Stretches	Road Length in Km	Category of Road	No. of Lanes	Combined LWP and RWP
1	**MM-MS**	Mandovi Motors -Bannerghatta Road to Military School in Hosur Road	5.2	Sub-arterial	4	10.4
2	**KMF-MHU**	Koramangala - Indiranagar intersection flyover to Marathahalli Underpass	7	Sub-arterial	4	14
3	**IISC-MC**	IISc to Mekhri circle	1.9	Sub-arterial	4	3.8
4	**CT-FO**	Cauvery Theatre Near Sadashivnagar to Forest Institute Office at Malleshwaram	2	Sub-arterial	4	4
5	**MC-HBL**	Mekhri Circle to Hebbal Flyover	5	Sub-arterial	4	10
6	**SMF-HB**	Sumanahally flyover junction to Housing Board Bus Stop	2.1	Sub-arterial	4	4.2
7	**HB-MH**	Housing Board Bus Stop to Modi Hospital Underpass	3.4	Other Roads	4	6.8
8	**KGP-VP**	Katriguppe (Food world Circle) signal to Vidyapeetha Traffic Signal	1.7	Other Roads	2	3.4
9	**SPS-BEL**	Sadashivnagar Police Station road to BEL Circle	3.6	Other Roads	2	7.2
10	**TVT-CRS**	T.V. Tower Matadahalli to Cantonment Railway Station	1.7	Other Roads	2	3.4
				Total Road Length in Kms		**67.2**

Data Collection for Stretches Under Study

- Pavement Distress such as Cracking, Rutting, Raveling, Potholes, Patching etc
- Functional Evaluation i.e. Surface Unevenness Measurement
- Structural Evaluation for measurement of Rebound Deflection of Pavement by means of Benkelman Beam Deflection Survey
- Classified Traffic Volume Count
- Axle Load Survey for Selected Stretches for estimating the Vehicle Damage Factor

Methodology & Work Plan

Selection of Road Stretches

Reconnaissance Survey

Preparation for Evaluation both Structural and Functional Surveys

Traffic volume count Survey

Pavement Condition Survey

Roughness Survey

BBD

Soil Testing

Analysis of Data

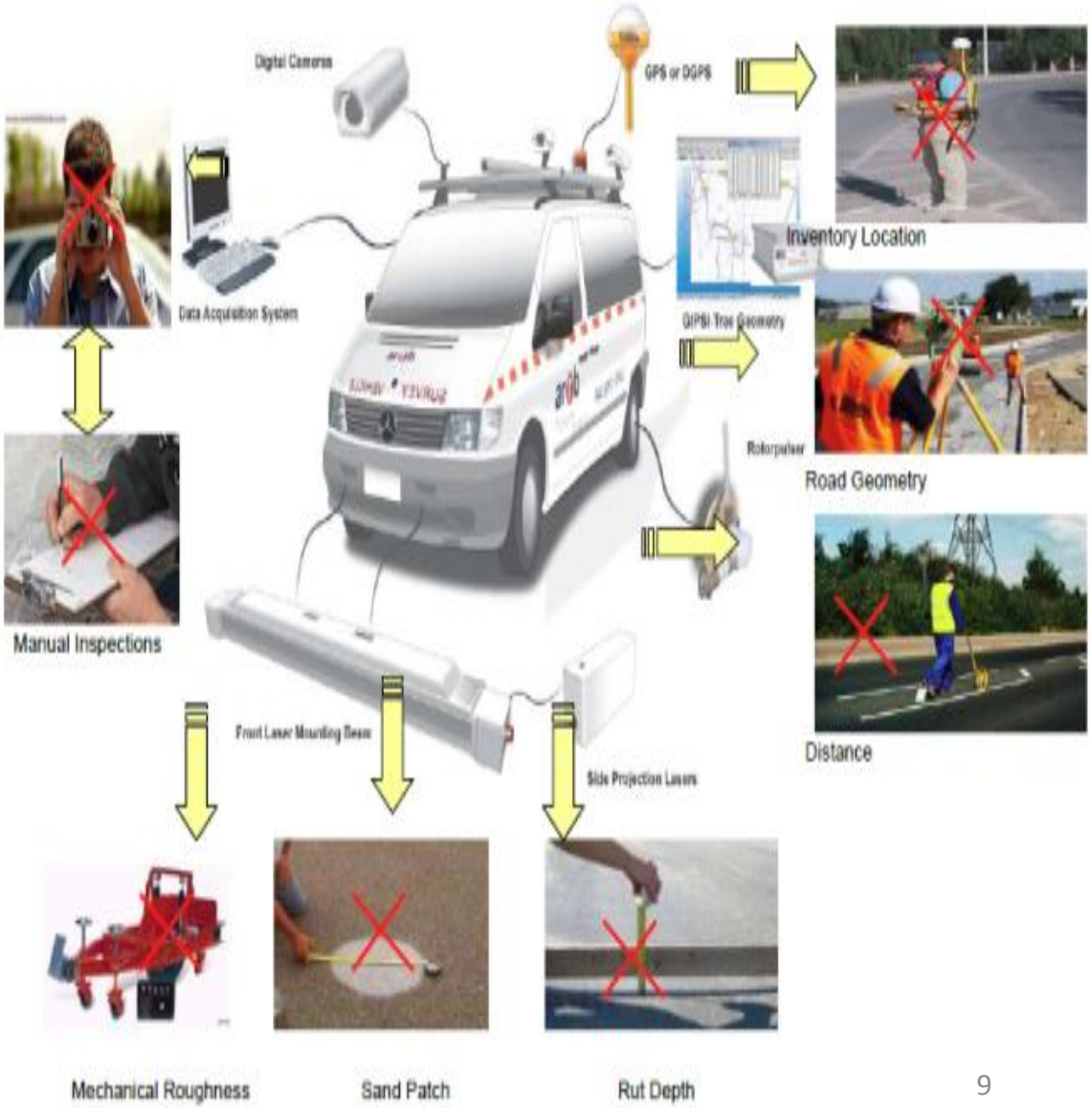
Collection of Different Cycles

Detail Analysis

Development of Models

HAWKEYE

An Integrated Approach to Replace Manual Assessments



IRSM Survey Vehicle

Hawkeye 2000 Methodology

Digital Laser Profiler

- Integrated into the NSV is a Digital Laser Profiler(DLP) consisting of eleven lasers. This inertial profiler is capable of measuring:
- Pavement roughness(one laser in each wheel path and centre)
- Rutting(full transverse pavement measurement)
- Macro texture (outer wheel path and between wheel paths)

Digital Imaging System

- Three cameras are forward facing and another onto the pavement which are capable of recording all the pavement defects and roadside assets at 5m interval.

Road Dimension Confirmation

- . The road length is automatically collected by the vehicles distance measuring instrument.

Distance and speed measurement

- The distance and speed measurement performed by the distance measuring instrument which is a distance transducer.

Defect Assessment

- The collected images/videos can be rated using the Hawkeye Processing Toolkit (HPT).

Details of Existing Crust Composition

Sl No.	Test Stretch, km	Existing Crust details, mm
1	Summanahalli Flyover to Kanteerava Studio – about 3.9km Length	WMM=250, BM=75, DBM = 50, BC = 40

PAVEMENT CRUST DETAILS OF THE PRESENT STUDY ROAD SECTION

SL No.	PAVEMENT DETAILS	Composition
1	Material Type	BM, DBM & BC
2	Most Recent Surfacing Thickness (mm)	165
3	Previous Surfacing Thickness	165
4	Last Reconstruction or New construction (Year)	2000
5	Last Rehabilitation (Overlay, Year)	2006
6	Last Resurfacing (Resealing ,Year)	2006
7	Last Preventive Treatment (Year)	2006

IRSM SURVEY VEHICLE DATA (04-02-2011)

Sl No	Descriptions	BEL-HBL (LHS)	HBL-BEL (RHS)
1	Average Bump Integrator (Unevenness)Value (mm/km)	1705	1830
2	Average IRI Value(m/km)	2.34	2.3
3	Average Rut value in mm	5.46	5.84
4	Average Grade %	-0.82	0.87
5	Average cross slope %	-0.73	-1.09
6	Average Horizontal Curve (1/km)	0.25	0.28
7	Average Vertical Curve (1/km)	0.02	0.04
8	Average Speed (km/h)	43.57	41.66
9	Average Latitude (deg)	13.05	13.05
10	Average Longitude (deg)	77.57	77.58
11	Average Altitude (m)	902.9	902.66

Volume Count Summary of SMF-KS

Traffic Data Summary					
Time	1st cycle	2nd cycle	3rd cycle	4th cycle	5th cycle
8--9 am	187	199	207	243	269
9--10 am	153	165	168	207	234
10--11 am	167	181	183	211	248
11-12 am	224	228	240	241	275
12--1 pm	162	179	165	222	267
2--3 pm	151	168	198	206	235
4--5 pm	203	223	210	308	315
5--6 pm	210	237	236	301	337
6--7 pm	192	168	213	302	345
7--8 pm	208	213	229	275	316
Total	1855	1960	2048	2513	2839

Traffic one day continuous count RESULTS

Sl No	Type of Vehicles	BEL-HBL (LHS)	Percentage (%)	HBL-BEL (RHS)	Percentage (%)	Total LHS+RHS
1	2-wheelers	7749	34.3	7350	39	15099
2	3-wheelers	911	4.0	730	3.8	1641
3	Car/jeep	7014	31.2	5762	30.6	12776
4	LCV	1226	5.4	1010	5.4	2236
5	Mini Bus	784	3.5	735	3.9	1519
6	Full Bus	810	3.6	604	3.2	1414
7	2-Axel Truck	2984	13.2	1950	10.4	4934
8	3-Axel Truck	718	3.2	439	2.3	1157
9	Multy Axel Truck	346	1.5	245	1.3	591
10	Tractor with trailer	17	0.1	13	0.1	30
	Total=	22559	100	18838	100	41397
	Total in PCU	32615		24853		57468

Weightage Factors for the Present Study

Weightage factors			
Distress	**Frequency**	**Serviceability factors**	**Weightage factors**
Pot holes	109	10	3.11
Roughness	60	8	1.71
Cracking	39	6	1.11
Patching	34	5	0.97
Ravelling	29	4	0.83
Rutting	15	2	0.43

PCI Formula

- PCI = [(Crack index * Weightage factor for cracking) + (Pot hole index * Weightage factor for pot hole) + (Ravel index * Weightage factor for Ravel) + (Rut index * Weightage factor for Rutting) + (Patching index * Weightage factor for Patching)]

Sample PCI Calculation for 2 Cycles.

Road Name: Nayandhalli – Silkboard(NDH-SB)

Chainage(km)	PCI Value		% decrease
	CYCLE-1	CYCLE-2	
0--1	78.44	77.56	1.12
1--2	79.12	77.56	1.97
2--3	79.59	77.52	2.60
3--4	84.05	82.44	1.92
4--5	86.21	84.42	2.07
5--6	82.23	80.19	2.47
6--7	82.69	79.16	4.26
7--8	80.12	78.05	2.59
8--9	79.28	77.94	1.70
9--10	80.92	77.25	4.53
10--11	76.28	73.64	3.46

Intervention Levels for Urban Roads

Sl No.	Serviceability Indicator	Arterial Roads
1	Deflection	1.0 mm
2	Roughness by bump integrator (max. permissible)	2000 mm/km
3	Cracking and Patch repairs (max. permissible)	5 percent
4	Potholes/km (max. number of size <100 sq.cm. and depth < 2.5 cm)	Nil
5	Rutting (max. permissible)	5 mm
6	Skid Resistance (Skid number by ASTM-274) minimum desirable	50 SN
7	User information	All road signs, road marking in good condition

Source :MORTH 2004

SUMMARY OF PAVEMENT SURFACE CONDITION DETAILS OF ALL STRECTHES

	Dec,2010 Manual	Feb, 2011 IRSM	Jun, 2011 Manual	Dec, 2011 IRSM	Apr,2012 Manual
Cracking %	1.40	5.06	1.51	5.09	3.73
Rutting mm	-	4	6	4	5
Roughness mm/km	2239	2287	-	2495	Pending
Ravelling %	0.20	0.30	0.63	1.11	1.24
Potholes numbers	4	3	3	6	1
Patching %	0.84	1.66	0.87	2.42	0.88
BBD mm	0.56	0.89	-	0.99	Pending

STATUS OF WORK PROGRESS

- **Two Cycles of Pavement Condition Evaluation completed by Use of *"Hawkeye 2000 Professional Network Survey Vehicle" procured from IRSM, Chennai, and Three cycles of Pavement Condition Survey by Manual Method.***
- **Classified Traffic Volume Count Survey of all Locations.**
- **Structural Evaluation of the Pavements using Benkelman Beam Deflection Survey technique for Arterial road for Three cycles.**

Application /Outcome of the Project

- **Pavement Deterioration Models will be developed after fifth cycle of data is collected for use in Pavement Management system for urban roads.**
- **To Prioritize the rehabilitation and reconstruction works and develop a framework for the pavement management system for urban roads.**
- **GIS mapping with precise representation of exisiting pavement deterioration and PCI values.**
- **Suggest priorities of maintenance for of roads sections based on pavement condition index and help in allocating/plan specific budget for maintaining authorities.**

Field Work Photographs


Thank You