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Technical Assistance for Implementation of
Institutional Reforms in the Road Sector of Uttar Pradesh

REPORT TO RE-ESTABLISH ANNUAL ROAD AND BRIDGE CONDITION AND TRAFFIC SURVEYS FOR CORE NETWORK (FINAL)

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Glossary

ADB	Asian Development Bank
ADT	Average Daily Traffic
AE	Assistant Engineer
BB	Benkelman Beam
BMS	Bridge Management System
BOOT	Build Own Operate Transfer
BOT	Build Operate Transfer
CBO	Community Based Organisation
CBR	California Bearing Ratio
CE	Chief Engineer
CEO	Chief Executive Officer
CRF	Central Road Fund
CRRI	Central Road Research Institute
CSR	Civil Service Reforms
DAO	Divisional Account Officer
DASP	Diversified Agriculture Support Program
DBC	Dense Bitumen Concrete
DPR	Detailed Project Report
DRDA	District Rural Development Authority
EC	Executive Committee
EE	Executive Engineer
E-in-C	Engineer in Chief
FWD	Falling Weight Deflectometer
GC	Governing Council
GIS	Geographic Information System
GPS	Global Positioning System
GNP	Gross National Product
GO	Government Order
GOI	Government of India
GoUP	Government of Uttar Pradesh
GSDP	Gross State Domestic Product
HDM	Highway Design Model
HGV	Heavy Goods Vehicle
HQ	Head Quarter
HR	Human Resource
HRD	Human Resource Development
HRM	Human Resource Management
IBRD	International Bank for Reconstruction and Development
IDS	Institutional Development Strategy
IDSP	Institutional Development And Strengthening Plan
IRC	Indian Road Congress
IRI	International Roughness Index
IT	Information Technology
ISAP	Institutional Strengthening Action Plan
ILO	International Labour Organisation
JE	Junior Engineer
LRP	Location Reference Points
LRS	Location Reference System
MDR	Major District Roads
MLA	Member of Legislative Assembly
MOST	Ministry of Surface Transport
MoSRTH	Ministry of Shipping, Road Transport & Highways
MoRTH	Ministry of Road Transport and Highways
MoEF	Ministry of Environment and Forest
M&E	Monitoring and Evaluation
MIS	Management Information System
MSS	Mixed Seal Surface
NABARD	National Bank of Agricultural and Rural Development
NITHE	National Institute for Training of Highway Engineers
NH	National Highway
NHAI	National Highways Authority of India
NOIDA	New Okhla Industrial Development Authority
ODR	Other District Road
O&M	Operation and Maintenance
PAC	Public Accounts Committee
PCC	Project Coordinating Consultant
PCI	Pavement Condition Index
PCU	Passenger Car – equivalent Unit
PICUP	Pradeshya Industrial & Investment Corporation of UP
PMS	Pavement Management System
PPP	Public Private Partnership
PRI	Panchayat Raj Institution
PSP	Private Sector Participation
PWD	Publics Works Department
RAP	Resettlement Action Plan
RES	Rural Engineering Services
RIDF	Rural Infrastructure Development Fund
RIS	Road Information System
RMMS	Road Maintenance Management System
RoMDAS	Road Measurement and Data Acquisition System
RoW	Right of Way
RSPEU	Road Safety Planning and Engineering Unit
RSC	Road Safety Cell
R&R	Resettlement and Rehabilitation
SDBC	Semi Dense Bitumen Carpet
SE	Superintending Engineer
SH	State Highway
SHA	State Highway Authority
SNP	Structural Number Parameter
SPV	Special Purpose Vehicle

SRF	State Road Fund
SRP-II	State Road Project-II
TA	Technical Assistance
ToR	Terms of Reference
UP	Uttar Pradesh
UPRNN	Uttar Pradesh Rajkiya Nirman Nigam
UPSBC	Uttar Pradesh State Bridge Corporation
UPSIDC	Uttar Pradesh State Industrial Development Corporation
UPSRTC	Uttar Pradesh State Road Transport Corporation
UPSRP	Uttar Pradesh State Road Project
UPSHA	Uttar Pradesh State Highway Authority
UNDP	United Nations Development Programme
VOC	Vehicle Operating Cost
VR	Village Roads
WB	World Bank
WBM	Water Bound Macadam

1. INTRODUCTION

1.1 BACKGROUND

The principal subject tasks identified as part of the Project covering the improvement of the PWD's road asset data for maintenance purposes are as follows:

Report No.	Effective network asset condition and traffic data
34	Re-establish annual road and bridge condition and traffic surveys for core road network
41	Review report on GIS-based road asset information system for core network
51	Monitoring report on Complete comprehensive update of ROW status and associated land use /planning/ownership data for core road network

The first task, the re-establishment of annual road & bridge condition and traffic surveys for the core road network is discussed in this Paper.

1.2 DATA FOR ROAD MAINTENANCE MANAGEMENT

Significant time and resources are required for data acquisition. Experience of implementing Road Maintenance Management Systems (RMMS) in other countries has shown that a simplified system, using the minimum necessary data, has more chance of being successfully implemented and of being sustainable.

The following 'types' of data are identified as necessary for an RMMS.

- Location Referencing
- Road Network data
  - Road Inventory
  - Drainage Inventory
  - Road Condition (Roughness and visual surface condition)
  - Pavement History
  - Pavement Strength
- Traffic (volume, composition, growth rate, axle load etc.)
- Project Information (status, costs etc.)
- Maintenance works undertaken and cost involved
- GIS-based base maps

As routine maintenance work on bridges is generally most effectively undertaken together with work on the roads, it is important to also collect and maintain bridge inventory and condition data.

1.3 SELECTION OF DATA ITEMS

The data items for each of the data types are selected based on their relative value to maintenance management. The grouping of the items shown in Section 1.2, above, is based on the best possible combination from point of view of network-level data collection and storage. Hence, the structure of database tables for RMMS is different from the table structure used in Management Information Systems [MIS]. A query facility can be built-in and used to transfer the required data between the RMMS and the MIS.

2. LOCATION REFERENCING SYSTEM

2.1 BACKGROUND

To ensure that data collected under different surveys are stored correctly in a database system and can be related and compared, it is important to have a standardised Location Referencing System (LRS) in place. Various process and analyses related to road management require cross-referencing of object and activity, which must be related to roads based on linear as well as spatial referencing methods.

2.2 LRS GUIDELINES FOR PWD

Development of standardised LRS guidelines for PWD will help to ensure that consistent approach is followed for easy data integration. Draft Guidelines are given in Annex 1. They include the basic principles to be followed for a location referencing and naming convention to be followed for linear referencing.

For the purpose of spatial referencing, Global Positioning System (GPS) co-ordinates of the road centreline will be used. For a network-level database, co-ordinates of the centreline at 100m intervals are generally considered adequate. It is also recommended to have GPS co-ordinates for all the identified Location Referencing Points (LRP).

A linear LRS, based on a road directory number identifier and a kilometre post number, is currently being used by PWD. To make it more generic and compatible with various analytical tools (including transportation planning software), it is preferable to implement an LRS based on **'Node-Link-Point'** principles. This is outlined below.

2.2.1. List of Nodes

Positional Nodes [at road-link end points], together with their identification codes (a unique five-digit number preceded by the letter N) should be defined on maps at major intersections (for example, in each major city, at National and State Highway junctions) where traffic characteristics change, and at district boundaries.

The data-table structure for definition of a node is given below in Table 2.1.

Table 2.1: Node Data Table: SysData_Node

Field	Description	Refer	Example
Node_ID	Node Identifier		NH001-SH008
Node_Name	Node Name		Parliament Junction, Rampur
Type	Node Type	LU_Node	Link Start/End
Location	Node Location		Parliament Junction
Description	Description		Parliament Junction at Palluatu
Photo	Link to photo file		C:\RIS\\Photo\Node\
Retired	Active/Inactive flag		0

2.2.2. List of Roads

The data-table structure for definition of a road is given below in Table 2.2.

Table 2.2: Road Data Table : SysData_Road

Field	Description	Refer	Example
Road_ID	L		SH008
Road_Name	Road Name		Rampur – Laxmanpur Road
Road_Type	Road Type		State Highway
From	Chainage at Start of Road in metres		0
To	Chainage at End of Road in metres		7233
Length	Road Length in metres		7233
Start_Point	Node at the Start of Road	SysData_Node	NH001-SH008
End_Point	Node at the End of Road	SysData_Node	SH008-K0346A

2.2.3. List of Links

The data-table structure for definition of a link is given below in Table 2.3.

Table 2.3: Link Data Table : SysData_Link

Field	**Description**	**Refer**	**Example**
Link_ID	Link (Unique) Identifier		SH008:LK0342A-K0344A
Link_Name	Link Name		SH008: From NH001Jn to Dual Cway Start
Description	Description		
From	Chainage at Start of Link in metres		0
To	Chainage at End of Link in metres		5340
Length	Link Length in metres		5340
Start_Point	Node at the Start of Link	SysData_Node	NH001-SH008
End_Point	Node at the End of Link	SysData_Node	SH008-K0344A
Road_ID	Road Identification	SysData_Road	SH008

2.2.4. List of Location Reference Points (LRP)

The LRPs could include prominent visual points or objects along a road, such as:

- Start of road (usually a 'virtual' point without a specific identifier)
- Kilometre post
- End of a bridge-deck
- Major road or street intersection
- Division or District border
- Monument or entrance to temple, school, etc.

The data table structure to keep definition of LRP is given in Table 2.4

Table 2.4: LRP Data Table : SysData_LRP

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link	SH008:LK0342A-K0344A
LRP_ID	LRP Identifier		SH008:K0343
LRP_Name	LRP Name		km Post 343
Type	LRP Type	LU_LRP	KMP
Description	Description		km Post 343
Offset	Offset from start of Link in metres		700
GPS_N	GPS co-ordinate Northing		
GPS_E	GPS co-ordinate Easting		
GPS_H	GPS Height		

2.2.5. Road Sections Based on Divisions

Divisions are the basic executive entity in PWD. Hence, it is essential that the road sections within a Division are well identified. The source data (SD) table structure to keep the definition of road section within a Division is given below in Table 2.5.

Table 2.5: Division-based Section data-table : SD_Division

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Lnk	SH008:LK0342A-K0344A
From	Chainage at Start of Link in metres		0
To	Chainage at End of Link in metres		5340
Div_ID	Division Identifier	LU_Division	2003

2.3 IMPLEMENTING A LOCATION REFERENCING SYSTEM

Before commencing the data collection, it is preferable to define Nodes, Links and LRP for all the roads included in the subject road network. Data collection based on predefined links and LRPs will considerably reduce the time and resource needs for processing the data to be entered into the referenced database system.

Preliminary identification of these LRS parameters will be undertaken as a desktop exercise, using available maps. The distance between LRPs will be defined based on data available in the MIS database, or in hard-copy records. Once the tentative LRS is defined, it may need to be verified for correctness by Division office, or through site-visit checking.

Survey for capturing GPS co-ordinates of the road centre lines and linear distance of the objects defined as LRP can be done simultaneously if automatic distance and co-ordinate measuring equipment is used.

3. ROAD NETWORK DATA

3.1 BACKGROUND

Systematic collection of data related to road inventory, road condition, pavement history and strength, based on standardised procedures and at the required frequency, is needed for credible network-level planning purposes.

Only a limited amount of road network data are currently available in PWD. Road inventory data are available for the core road network, but only in hard copy form. Condition and traffic data, collected as part of various studies and projects, are available for very limited length of road.

Review of the PWD MIS[1] Planning Module database showed that only data related to road name, road class and Division are available for a total length of road of approximately 8000 km.

No functioning automatic road survey equipment could be located in PWD. An ARAN vehicle, used for survey of the UP road network as part of the 'Four State PMS' Project in 1994-96, is believed to be currently in Rajasthan and not in operational condition.

Current PWD projects are utilising external service providers to carry out the data collection. For example PWD appointed CRRI to undertake a study titled 'Impact Assessment of rehabilitation works on vehicle overloading, travel times and road roughness (February 2006). A similar approach can be followed for collection for network-level planning data.

It is very important that the necessary quality control procedures (with strict equipment and surveyor calibration requirements) are included in the contract documents to ensure that the data provided are reliable. Review of a long-term maintenance programme for the core-network (prepared by consultants in March 2006 showed some inconsistency between the network conditions and the work programme generated by DHV software 'Road Manager'. The present condition status of the road network shows a significant backlog of work needed, whereas work is programmed mainly from 2008 onwards. Visual condition data, collected in an incorrect format, was blamed in the report for the poor analysis results developed by the software program.

3.2 ROAD INVENTORY

3.2.1. Introduction

A Road Inventory provides listed physical characteristics of each numbered and identified road in the network and is needed as base information in any road management related analysis.

1 A Management Information System was developed by consultants in 2002, but has not yet been implemented in PWD

3.2.2. Data Table Structure for Inventory

The data items to be collected during a road and drainage Inventory survey are summarized in Table 3.1 and Table 3.2, below

Table 3.1: Roadway Inventory Data: SD Inventory

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link.[Link_ID]	SH008:LK0342A-K0344A
From	Section start chainage (m)		42455
To	Section end chainage (m)		42493
Terrain	Flat/Rolling/mountainous	LU_Terrain.[Code]	F
Cway Width	Carriageway width (m)		12.2
Shld Width	Shoulder width (m)		0
Surface Type	AC/Surface Treat/PM/Primed	LU_SurfType.[Code]	AC
HDMP Type	HDM-4 Pavement type	LU_HDM_PavType.[Abrv]	AMSB
Shld Type	Shoulder type	LU_ShldType.[Code]	
Lanes	Number of lanes		4
Rd EnvType	Central Urban/Outer Urban/Rural	LU_RoadEnv.[Code]	CU
Climate	Climate zone	LU_ClimateZone.[Code]	
ROW	Right of Way width [m]		0
RecordDate	Survey Date		30/12/2005
RecordBy	Surveyed By		Nabin

Note: See Annex 2 for the Refer-to tables.

Table 3.2: Drainage Inventory Data : SD Drainage

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link.[Link_ID]	SH008:LK0342A-K0344A
From	Section start chainage (m)		42455
To	Section end chainage (m)		42493
DrnType	Nill/Lined/Unlined/Not Req	LU_DrnType.[Code]	
Clv_Num	Number of culverts		4
SbMrg	Submergence in % length		100
RecordDate	Surveyed Date		30/12/2005
RecordBy	Surveyed By		Nabin

Note: See Annex 2 for the Refer-to tables.

3.2.3. Collection of Road Inventory Data

Road Inventory data will be collected either by PWD Division offices, or an external service provider, preferably at the same time as the collection of road condition data.

With the no specific equipment required, except a simple distance measuring instrument, the roadway inventory data can easily be collected by appropriately trained personnel. Inventory data collection is a one-off process. Once data is available in the system, it should be updated only when there is change in the characteristics of the road network. The inventory data, made available in RIS, can be verified at the time of the visual condition data collection survey.

3.3 VISUAL ROAD CONDITION DATA

3.3.1. Introduction

The *current* visual road condition is a major parameter for assessing the *future* condition of each road segment and for programming short-term road work. Accordingly, the visual condition survey should be carried out <u>at least once a year, prior to programming</u> the works for the following year. One particular approach is to carry out the condition survey <u>per km section,</u> preferably after the monsoon season, from a slow moving vehicle. However, the final 100 m of each km length could be surveyed on foot to confirm the assessment of the whole km section.

The tasks involved are:

- Assessment of road distress types and extent [Standard Forms are given in Annex 3 to this Report]
- Local encoding of the data (using MS Excel or MS Access templates)
- Bulk import of electronic data to the RMMS database

Visual data collection carried out for earlier maintenance programmes followed a complicated condition-rating system based on published Guidelines. This included a consideration of severity requiring technical judgement to define condition level. Such a system [used in developed countries] needs highly trained data collectors to ensure reliable data.

A simplified visual condition-rating method should be introduced for use by UP PWD for network level planning process. Such a method has been successfully used by Gujarat Road and Building Department (R&BD) for the Gujarat Road Management System (GRMS) in 2004-05.

3.3.2. Distress Types

The distress type and criteria for visual assessment of the surface condition are summarised in Table 3.3 and Table 3.4, below.

Table 3.3: Bituminous Pavement Distress

Typical Bituminous Pavement Distresses	Severity		
Types/Definition	**Code**		**Assessment**
Failed Sections (evidence of road base failure):	0	None	None or few isolated spots (< 5 m2/km)
Distressed (crack width > 12 mm) or deformed road surface where depth is greater than 75 mm and exceeding 1 m2	1	Low	Failed in less than 10% of road length
	2	Med	Failed in 10-50% of road length
	3	High	Failed in more than 50% of road length
Cracking (sealed & unsealed, of longitudinal trend Random cracks and 'alligator' cracks)(1)	0	None	No cracking or few isolated spots (< 5 m2/km)
	1	Low	Cracking in less than 10% of road length
	2	Med	Cracking in 10-50% of road length
	3	High	Cracking in more than 50% of road length
Ravelling (breaking-out of bound aggregates or severe loss of surface dressing)	0	None	None or few isolated spots (< 5 m2/km)
	1	Low	Ravelled in less than 10% of road length
	2	Med	Ravelled in 10-50% of road length
	3	High	Ravelled in more than 50% of road length
Potholes (bowl-shaped holes, broken out >	0	None	None or few isolated shallow

Typical Bituminous Pavement Distresses	Severity		
Types/Definition	**Code**		**Assessment**
100cm2 in area			potholes (< 5 m2/km)
and >25 mm in depth) [(2)]	1	Low	Occasional deep potholes
Shallow: within the wearing course.	2	Med	Frequent deep potholes affecting vehicle speed
Deep: within the base course.	3	High	Potholes spread across carriageway (comfortable speed: <30 km/h)
Pavement Edge Break (break width >10 cm)	0	None	None or few isolated spots (< 5 m/km)
	1	Low	Edge break in less than 10% of road length
	2	Med	Ravelled in 10-50% of road length
	3	High	Ravelled in more than 50% of road length
Rutting (wheel path longitudinal depression, depth >20mm)	0	None	None or few isolated spots (< 5 m/km)
	1	Low	20 mm or more rutting in less than 10% of road length
	2	Med	20 mm or more rutting in 10-50% of road length
	3	High	20 mm or more rutting in more than 50% of road length
General Condition of Drainage Structures (for HDM use only)	0	Exc	Drainage functioning effectively
	1	Good	Effective in more than 90% of road length
	2	Fair	Effective in 50-90% of road length
	3	Poor	Effective in less than 50% of road length

(1)Severe cracks rated under "Failed Sections" are not rated again under "Cracking"; potholes within the Failed Sections are excluded when rating "Potholes"

(2)Irregularities less than 100 cm^2 in area or less than 25 mm in depth are considered under "Ravelling"

Table 3.4: Unsealed Pavement Distress

Typical Gravel/Earth Roads Distresses	Severity		
Types/Definition	**Code**		**Assessment**
Reconstruction needed (Failed Sections)	0	None	None or few isolated spots (< 5 m2/km)
Deep irregularities within gravel surface and into sub-grade.	1	Low	Failed in less than 10% of road length
Comfortable speed is less than 30 km/h i	2	Med	Failed in 10-50% of road length
	3	High	Failed in more than 50% of road length
Minor Shaping needed (Re-grading)	0	None	No need or few isolated spots (< 5 m2/km)
Minor irregularities on road surface.	1	Low	Need in less than 10% of road length
Comfortable speed is less than 70 km/h	2	Med	Need in 10-50% of road length
	3	High	Need in more than 50% of road length
Regravelling needed	0	None	No need or few isolated spots (< 5 m2/km)
Not maintainable by regrading due to excessive irregularities and/or insufficient. thickness of surface gravel. Comfortable speed is less than 50 km/h .	1	Low	Need in less than 10% of road length
	2	Med	Need in 10-50% of road length
	3	High	Need in more than 50% of road length

3.3.3. Data Entry and Updating

Road Condition Data collected will be entered into a specific template built using MS Access. The data will then be bulk-imported into the RIS database. It is proposed to keep historic data for 5 years.

Tabulation will be as shown in the Table 3.5 and Table 3.6, below

Table 3.5: Bituminous Surface Condition Data : SD Condition

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link. [Link_ID]	SH008:LK0342A-K0344A
From	Section start Chainage(m)		42455
To	Section end chainage(m)		42493
Failed	Failed Sections (scale 0 – 4)		
Cracking	Cracking (scale 0 – 4)		0
Raveling	Raveling (scale 0 – 4)		0
Potholes	Potholes (scale 0 – 4)		0
EdgeBreak	Edge break (scale 0 – 4)		0
Rutting	Rutting (scale 0 – 4)		0
Drainage	Drainage (scale 0 – 4)		0
Comments			
RecordBy	Record/Surveyed By		PIYATISSA
RecordDate	Record/Surveyed Date		19-Nov-05

Table 3.6: Unsealed Surface Condition Data – SD_Condition_Unseal

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link. [Link_ID]	SH008:LK0342A-K0344A
From	Section start Chainage(m)		42455
To	Section end chainage(m)		42493
Nd_Recon	Need for reconstruction (scale 0 – 4)		0
Nd_MnShp	Need for Minor Reshaping (scale 0–4)		0
Nd_ReGrv	Need for Regravelling (scale 0 – 4)		0
Rough_Clss	Roughness Class (scale 0 – 4)		0
Comments	Remarks		
Record By	Record/Surveyed By		PIYATISSA
Record Date	Record/Surveyed Date		19-Nov-05

3.3.4. Collection of Visual Condition Data

Visual Condition data will be collected either by PWD Division offices, or an external service provider, preferably at the time of collection of Road Condition data.

As with collecting road inventory data, no specific equipment is required for visual condition data, except simple distance measuring instrument. However, due to subjective nature of the visual condition data, the personnel assigned should be well trained. If PWD resources are employed, a Data Collection Cell needs to be setup up in head-quarters for coordinating training and the collection process.

Before the start of data collection by a contractor, the personnel should be fully trained and be provided with the Road, Link and LRP lists and suitable quality control procedures should be in place.

3.4 ROAD ROUGHNESS

3.4.1. Introduction

Road surface ride-quality ('Roughness') is the most important condition parameter influencing road user comfort and, more importantly, vehicle operating costs [VOC]. The International Roughness Index (IRI) is a reference measure of the road surface shape that resulted from an international study funded by the World Bank. The IRI is a measure of the impact of the road profile on the ride and dynamic response (vertical movements) of a moving vehicle. The IRI is expressed in m/km. A typical range of IRI values is:

- Paved roads: 2 to 4 (ideal) - 14 (a failed road)
- Unpaved roads: 6 to 10 (ideal) - 24 (a failed road)

The most commonly used equipment for roughness measurements are:

- Bump Integrator (such as ROMDAS or TRRL)
- Laser Profilometer

The Bump integrator is a cost-effective piece of equipment and provides data of reasonable accuracy for network-level planning purposes.

The data table to store the Roughness data in is given in Table 3.7 below.

Table 3.7: Roughness Data : SD_Roughness

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link.[Link_ID]	SH008:LK0342A-K0344A
From	Section start Chainage(m)		42455
To	Section end chainage(m)		42493
IRI_Avg	Average IRI value		4.513132
RecordDate	Record/Survey Date		12/01/2005
RecordBy	Record By		Nabin
SurvNum	Survey Number		2
Bump_Incr	Bump Indicator reading _Increasing		396
Bump_Decr	Bump Indicator reading _decreasing		376
Coef_Set	Coefficient Set	LU_RoughCoef	0

A roughness assessment for gravel roads is recorded with the visual condition data. An actual roughness measurement of gravel roads is considered as not needed.

3.4.2. Collection of Roughness Data

Roughness surveys should be carried out once a year for the entire core road network. For the remaining paved State Highways and Major District roads, it could be carried out once in 2 years if there is constraint in funding.

An external service provider can be used to carry out the Roughness measurements. The contract document for procuring the services should define the quality control process to be followed while calibrating the equipment and validating the collected data.

3.5 PAVEMENT HISTORY

3.5.1. Introduction

Pavement history data is essential for lifecycle modelling of the pavement in order to produce an optimal work programme for maintenance.

Data related to pavement history should be collated in the format shown in Table 3.8, below.

Table 3.8: Pavement Data : SD_PvHistory

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link.[Link_ID]	SH008:LK0342A-K0344A
From	Section start Chainage(m)		42455
To	Section end chainage(m)		42493
LstWC_Thck	Last Wearing Course Thickness in mm		30
Recon_Year	Reconstruction Year		1980
Rehab_Year	Rehabilitation Year		1980
Resurf_Year	Resurfacing year		1980
RecordDate	Record/Survey Date		12/05/2001
Defl_Mean	Mean BB Deflection in mm		1
Defl_STD	Standard Deviation of BB Deflection		0.5
LstWC_Type	Last Wearing Course Type	LU_SurfType	
OldWC_Thck	Old Wearing Course Thickness in mm		50
BitBs_Thck	Bitumen Bound Base Thickness in mm		0
AgrBs_Thck	Aggregate Base Thickness in mm		150
SbBs_Thck	Sub Base Thickness in mm		200
SGr_Type	Sub Grade Type		
Pav_Type	Pavement Type	LU_PaveType	
SGr_SokCBR	Sub Grade Soaked CBR%		
SGr_UnSCBR	Sub Grade UnSoaked CBR%		10
Refer	Reference		
Record By	Record By		Nabin

Note: Fields below the thick line are optional

3.5.2. Collection of Pavement History Data

Initially, the pavement history data need to be collated by PWD Divisions. Then the updating of the data will be based on 'as-built' information and on other information provided by PWD on the major maintenance work carried out in the particular section.

3.6 PAVEMENT STRENGTH DATA

3.6.1. Introduction

The structural strength of the pavement is an important parameter for assessing the future performance and the need for strengthening of a road section. Both ASTHOO and HDM-4 procedures use the structural number parameter (SNP) as a pavement strength (performance) variable.

Comparing the pavement strength required for a given traffic loading level with the strength of the existing pavement structure, will allow potential sections requiring strengthening to be identified. A more detail study of the strengthening requirement of the road, based on IRC Code 81, will be required, if a particular road is selected for maintenance treatment.

A 'reference' table (Table 3-8 for example) that will define the pavement strength requirement for a given traffic level will be established. Two threshold values of SNP are given in Table 3.9, below. Pavements with a strength less than the 'Min_Low' threshold will be considered for strengthening. On the other hand, for pavements with a strength less than 'Min_High' value should be considered only for resurfacing.

Table 3.9: Pavement Strength (SNP) Need : LU_StrengthNeed

Traffic Class	Traffic_Description	Min_Low	Min_High
1	LT 750 veh/day	2.7	3.2
2	750 – 2500 veh/day	3.2	3.7
3	2500 – 10,000 veh/day	3.7	4.2
4	10,000 – 20,000 veh/day	4.2	4.7
5	GT 20,000 veh/day	4.7	5.2

3.6.2. Measuring Pavement Strength

Pavement types are basically defined by the following:

- Paved (Bituminous): type and thickness of its three constituent layers; surfacing, road base, and sub-base.
- Unpaved: surface material type and thickness, type and thickness of base material.

This information can be collected from relevant documentation [if reliable], secondary sources (such as a works supervision report), or from site investigations.

Since 'as-built' information is rarely available, calculations of pavement strength will be carried out based on deflection measurements, using either-

- Static loading : by Benkelman Beam (BB) or,
- Dynamic loading : by Falling Weight Deflectometer (FWD).

Though less accurate and slower, BB-deflection is more commonly used in India due to the equipment being lower in cost and simpler than the FWD. Deflection data can be stored as shown in Table 3.10, below.

Table 3.10: Benkelman Beam Data – SD_BBeam

Field	Description	Refer	Example
Link_ID	Link Identification	SysData_Link.[Link_ID]	SH008:LK0342A-K0344A
From	Section start chainage(m)		450
BBD_Avg	Benkelman Beam Deflection value(average)		0.3
RecordDate	Record Date		12/5/2006
BBD_IL	Benkelman Beam Deflection value(increasing)-Left		0.5
BBD_IR	Benkelman Beam Deflection value(increasing)-Right		0.4
BBD_DL	Benkelman Beam Deflection value(decreasing)-Left		0.3
BBD_DR	Benkelman Beam Deflection value(decreasing)-Right		0.2
Recordby	Record/Surveyed by		Nabin
Latest	Latest data (Yes/No)		No

Note: Fields below the thick line are optional

For network-level data collection, the following tests will be carried out:

- Deflection measurement every 500 m
- One test pit in the middle of every 5 km section.
- The section length could be less if surface, or pavement type, traffic class, or condition, changes significantly. Pavement composition, type and sub-grade soil will be logged. and sampling sub-grade soil;
- Classification (based on Indian Soil Classification System) of sub-grade soil in each test pit[2]

3.6.3. Typical Pavement Design Method

Collection of as-built information, as well as deflection data, is generally not possible for the whole network. Estimates for pavement design can be based, for example, on the Typical Pavement Design method (TPDM). Although not very accurate, this method could be used when no other information is available as it is a rough empirical approach using an assessments of the pavement configuration and the sub-grade strength.

The user selects one from a number of typical configurations of pavement type as being representative of the pavement for a given section. The sub-grade category also needs to be chosen, based on strength (high, medium or low). Depending on the combination selected, the design thickness of pavement is typically assigned as shown in Table 3.11, below.

Table 3.11: Default SNP for Typical Pavement Design Method

Pavement Type	Layers	Effective Thickness (mm)	Subgrade Strength		
			Low	Medium	High
			3< CBR < = 7	7 < CBR <= 15	CBR > 15
Surface Treatment and Non-Structural Asphalt					
ST0	Seal	25	1.1	1.7	2.1
	Base	50			
ST1	Seal	25	1.5	2.1	2.6
	Base	150			
ST2	Seal	25	2.3	2.9	3.4
	Base	150			
	Subbase	150			
ST3	Seal	25	2.6	3.2	3.6
	Base	150			
	Subbase	250			
ST4	Seal	25	3.0	3.5	3.9
	Base	200			
	Subbase	300			
Structural Asphalt					
AM1	Asphalt mix	50	2.1	2.7	3.2
	Base	150			
AM2	Asphalt mix	50	2.9	3.5	4.0
	Base	150			
	Subbase	150			
AM3	Asphalt mix	50	3.2	3.7	4.2
	Base	150			
	Subbase	250			

Pavement Type	**Layers**	**Effective Thickness**	**Subgrade Strength**		
		(mm)	**Low**	**Medium**	**High**
			3< CBR < = 7	**7 < CBR <= 15**	**CBR > 15**
AM4	Asphalt mix	50	3.6	4.1	4.5
	Base	200			
	Subbase	300			

Notes: The following values were assumed while calculating SNP:

1. **Strength coefficient a1**

   ST 0.2

   AC 0.4

2. **Values of CBR by layer:**

   Base 100%

   Subbase 50%

   Subgrade:

   - Low Strength 5%
   - Medium Strength 10%
   - High Strength 20%

3. **Subgrade with stabilisation is considered as high strength.**

3.6.4. Typical Pavement Design Data

Sufficient data for the TPDM may be available in PWD Divisions. Technical personnel working in a Division for long time should have some idea of the pavement structures and the various subgrade characteristics of the roads in the Division.

The data table structure for TPDM is given in Table 3.12, below

Table 3.12: Typical Pavement Design Data : SD_TPDM

Field	Desc	Lookup	Example
Link_ID	Link Identification	SysData_Link. [Link_ID]	SH008:LK0342A-K0344A
From	Section start chainage (m)		450
To			
PvType	Typical pavement type	Lu_PvType	ST1
SubStrn	Subgrade Strength	L/M/H	M
RecordDate	Record Date		12/5/2006
RecordBy	Recorded by		Nabin

4. TRAFFIC DATA

4.1 INTRODUCTION

Traffic data is one of the most important sets of data used for road planning, design and maintenance management. The collection described here is mainly limited to requirements of network level maintenance planning purposes. More detailed data on traffic will be required for pavement or bridge design and transport planning purposes.

4.1.1. PWD Current Practice

PWD carries out a traffic census in accordance with IRC: 9 -1972, which is a repetitive 7-day count, taken twice a year; once during the peak season of harvesting and marketing, and the other during the low season, at pre-selected stations. The operations are generally intended to embrace only the important trunk routes, such as National Highways, State Highways and Major District Roads. No definite criteria are laid down for the number of census stations.

Traffic counts are conducted based on the vehicle fleet grouped into the following types:

- Cars, Jeeps, Vans,
- Buses
- Trucks
- Motorcycles and scooters
- Three wheelers
- Animal drawn
- Bicycles

Considering there is a huge difference of loading characteristics within each of the vehicle types, some of the types will be further sub-divided for the UP RMMS

Current traffic data is limited and not available in a systematic data base format. PWD is collecting traffic data only for those sections where works are planned to be undertaken in the near future.

4.1.2. Traffic Data Tables

The data table structure for Traffic Volume and Distribution data is given in Table 4.1, below

Table 4.1: Traffic Volume and Distribution Data : SD_Traffic

Field	Description	Refer	Example
Link_ID	Link Identifier	SysData_Link.[Link_ID]	SH008:LK0342A-K0344A
From	Section start Chainage(m)		42455
To	Section end chainage(m)		42493
Location	Location of Traffic Count station		T2095
AADT_Year	Year of ADT counting		2005
AADT_MOT	AADTription for motorised vehicles		20000
Pc_MCl	Motorcycles in % of AADT_MOT		10
Pc_3Wl	Three wheelers in % of AADT_MOT		10
Pc_Car	Cars in % of AADT_MOT		10
Pc_Van	Van or Pickup in % of AADT_MOT		10
Pc_MBus	Medium Bus in % of AADT_MOT		10
Pc_LBus	Large bus in % of AADT_MOT		10
Pc_MGV	Medium Truck in % of AADT_MOT		10
Pc_HGV	Lorries in % of AADT_MOT		10
Pc_ART	Articulated Truck in % of AADT_MOT		30
AADT_NMT	ADT count for non-motorised vehicles		1100
Pc_Crt	Animal drawn vehicle in % of AADT_NMT		10
Pc_Cycles	Bicycle and rickshaws in % of AADT_NMT		90
RecordBy	Record By		
RecordDate	Record/Survey Date		
DataSource	Data Source (Count/Estimate)	List	

Note: Fields below the thick line are optional

Traffic growth rate is calculated based on predicted economic growth, analysis of the historic traffic counts and plans for future development of the area. Hence, the same traffic growth rate is used for a sub-network and network for planning purposes. Hence, growth data can be kept in a reference table with the dataset identifier. (See Table 4.2 below).

Table 4.2: Traffic Growth Data : SD_Traffic

Field	Description	Refer	Example
Set_ID	Set Identifier		
From Year	From Year		
To_Year	To Year		
AADT_MOT	AADT for motorised vehicles		
Gwth_3Wl	Three wheelers in % of AADT_MOT		
Gwth_MCl	Motorcycles in % of AADT_MOT		
Gwth _Car	Cars in % of AADT_MOT		
Gwth _MBus	Medium Bus in % of AADT_MOT		
Gwth _LBus	Large bus in % of AADT_MOT		
Gwth _Van	Van in % of AADT_MOT		
Gwth _MGV	Medium Truck in % of AADT_MOT		
Gwth _HGV	Lorries in % of AADT_MOT		
Gwth _ART	Articulated Truck in % of AADT_MOT		
RecordDate	Record/Survey Date		
DataSource	Data Source (Count/Estimate)	List	

Note: Fields below the thick line are optional

Collection of axle load information is required to define vehicle damage factor (VDF). These data can be stored in a database table, based on the format of data collection. The average VDF value for different vehicle type is used to calibrate the HDM-4 Road User Effects model.

4.1.3. Collection of Traffic Data

For the collection of the traffic data, the road will be divided into 'Traffic Sections' based on a major change in traffic volume, or traffic composition. For very highly trafficked roads, seven days manual classified traffic count, twice a year, as specified by IRC, will be undertaken. For remaining roads of the core network a 3-day count (to include one weekend day) is generally sufficient.

For defining the seasonal variation, a permanent, automatic traffic counting station, collecting the data all the year round should be established by PWD. Ten such stations in the core network is recommended in the initial stage.

5. OTHER DATA

5.1 PROJECT INFORMATION

5.1.1. Introduction

Progress on the various ongoing works are presently monitored by PWD in paper based format. Only the financial progress records for projects under World Bank funding have been found in electronic format.

Project information, such as current progress status, funding allocated and expended, work type, location etc. are necessary for gradual building-up of pavement history and to identify which of the road sections will be excluded from the next annual work programme.

5.1.2. Data Table Structure

The data table structure for Project Information table is given in Table 5.1, below.

Table 5.1: Project Information Summary : SD_ProjInfo

Field	Description	Refer	Example
Link_ID	Link Identification	SysData_Link.[Link_ID]	SH008:LK0342A-K0344A
Proj_ID	Project Identification		P_Sh008_04/1
Proj_Name	Project Name		2nd Road Project
From	Section start chainage(m)		42455
To	Section end chainage(m)		42493
Work_Catg	Work Category	LU_WorkCatg	IMP
PrjStatus	Project status (ongoing/completed/abandoned)		Ongoing
PrjStartDT	Project start date		21/1/2004
PrjEndDT	Project end date		31/12/2008
TlEst_Cost	Total estimated cost (Rs Mln)		1,000
TExp_LstYr	Total expense up to last year (Rs Mln)		455
Bgt_CuYear	Budget current year (Rs Mln)		200
Bgt_NxYear	Budget Next year (Rs Mln)		200
Prj Progrss	Physical Project progress		50&
Record Date	RecordDate		

Note: Data items below thick line are optional

5.1.3. Collection of Project Information Data

Progress reports sent by various PWD Divisions and project offices will be used for initial collation of project information. Enquiry to the responsible authority might be needed to fill the gaps or verify the information.

5.2 UNIT COSTS

5.2.1. Introduction

Unit costs are the basic cost estimate indices of all the work, materials, plant and labour charges to undertake the works. They are normally collected from ongoing and past works by external contractors, but could be extracted from PWD conducted works if such information is recorded. Without these figures, cost estimates of the work programme will not be possible. These data must be updated annually.

5.2.2. Data Table Structure

The table structure to hold the unit cost data is given in Table 5.2, below.

Table 5.2: Unit Cost : LU_UnitCost

Field	Description	Refer	Example
Set_ID	Unit Cost Set Identifier		
Work_Type	Work Treatment Type	LU_WorkType	
Work_Cat	Work category	LU_WorkCat	
Unit	Unit of measurement for given work type	LU_Unit	
Finn_Rate	Financial unit cost in Rs.		2000.90
RecordDate	Recorded Date		20/01/2005
Econ_Rate	Economic unit cost in Rs		
Comment	Comments		

6. BRIDGE DATA

6.1 BACKGROUND

A Bridge Management System (BMS) is used to record the changing condition and maintenance history of bridge structures. It is understood that PWD is initially planning to implement only road maintenance management, data related to road bridges will be collected and stored in the Road Information System (RIS).

6.2 REFERENCING BRIDGES

Bridges are referenced as a point on the road. The chainage at the starting point of the first span of the bridge (in increasing direction) is considered as the location of the bridge for linear location referencing purposes. For spatial referencing the GPS co-ordinates at each end of the bridge, on the centre line, are recorded.

Table 6.1: Bridge Referencing Data : SD_Bridge

Field	Description	Refer	Example
Link_ID	Link Identifier		DF330204
From	From Chainage (m)		500
Struct_ID	Structure Identifier		B_DF330204_010
Struct_Type	Structure Type	LU_BMS_StrucType	B
Struct_Name	Structure Name		Gabagaba Bridge No 1
Length	Total Length of Bridge (m)		33
Obst_Type	Obstacle Type	LU_BMS_ObsType	STRM
Obst_Name	Obstacle Name		Kopugolo creek
GPS_Lo_Lat	Latitude – Low chainage		09 47.816
GPS_Lo_Long	Longitude – Low chainage		147 32.816
GPS_Lo_Alt	Altitude – Low chainage		16.5
GPS_Hi_Lat	Latitude – High Chainage		09 47.823
GPS_Hi_Long	Longitude – High Chainage		147 32.802
GPS_Hi_Alt	Altitude – High Chainage		16.5
Comments	Comments		

6.3 BRIDGE INVENTORY DATA

The table structure (as shown in Table 6.2 for Bridge Inventory Data collection was prepared following IRC Note No. 35 and based on the potential use of the data. Only the minimum level of data will be collected initially, sufficient to ensure that the required information for maintenance planning is available.

Table 6.2: Bridge Inventory Data Table : SD_BrgInv

Field	Description	Refer	Example
Struct_D	Structure Identifier		B_SH008_010/1
Insp_Name	Inspector Name		HB
RecordDate	Inspection Date		28/04/2004
Brg_Type	Bridge Type	LU_BMS_ConstType	BALY
Cnstr_Year	Construction Year		2003
Num_Lane	Number of Lanes		1
Brg_Width	Bridge Width (m)		0
Num_Span	Number of Spans		1
Length	Total Length of bridge (m)		33.5
Comment	Remarks		Compact 200,

7. PROPOSED DATA COLLECTION PLAN

7.1 A PILOT IMPLEMENTATION OF DATA COLLECTION

To test the effectiveness of the described data collection procedures and the appropriateness of the collected data for use in an RMMS, it is proposed that a Pilot scheme be put in place on the UP road network. This is not part of the current TA Project. Based on the findings from the Pilot scheme, any refinement needed to the system can be undertaken before implementing it generally on the whole PWD network. The part of the strategic core network without on-going construction projects is proposed as the source of pilot roads.

Table 7.1: Pilot Data Collection Responsibility

Data	Responsibility
LRS Data	Division or Contract out
Road Inventory Data	Division or Contract out
Roughness Data	Contract out
Visual Condition Data	Division or Contract out
Pavement Strength Data	Contract out
Project Info Data	Division
Unit Cost	Division
Maintenance Cost and Quantity	Division
Bridge Data	Division or Contract out

Note: All other data to be collected once LRS is finalised.

7.2 RESOURCES FOR DATA COLLECTION

A dedicated set of PWD officers should be assigned full-time for the systematic collection and analysis of data for maintenance planning purposes. It is proposed that a GIS/RMMS Unit be created at the PWD head- quarters and selected personnel assigned to it.

Personnel training will be required, to -

- understand the data requirements and its importance
- enhance their capability with the methods of collection
- enhancing their ability to quality-check data from external service providers

In view of the existing capability of PWD, it is likely that most of the required data collection will be carried out using external service providers. A cost estimate for the data collection on the core network is given in Annex 4. Allocation of the funding as soon as possible is an urgent requirement to ensure progress.

8. ISSUES RAISED BY THE FOCUS GROUP

At the meeting of Focus Group H on Thursday 10th May 2007 the following issues was raised:

1 Clarification of what data it was considered should be collected by the PWD.

The following is a list of Data Requirements for Road and Bridges under the heading of Inventory Surveys, Condition Surveys, and Traffic Surveys:

<u>Inventory Surveys: Roads</u>

- Carriageway
  - Carriageway Type
  - Wearing course - type and thickness
  - Road base - thickness
  - Width of Road
- Road Junction details - type of intersection
- Horizontal curve details
- Vertical curve details
- Drainage
  - Type
- Shoulder
  - Type
  - Width
- Footpath
  - Type
  - Width
- Distance of PWD boundary from Centre Line of carriageway
- Land Use
- Terrain
- Embankment / Cutting

<u>Inventory Surveys: Bridges</u>

- Structure
  - Year of construction
  - Number of Spans, Clear Span
  - Length of Bridge
- Superstructure
  - Type of Bridge
  - Type of Material
  - Thickness
- Sub-structure
  - Type of Abutment
  - Type of Pier

- Foundation
  - Type
  - Construction Details
- Wingwall Type
- Railing / Parapet Type
- Crash Barrier
- Wearing Course
  - Type
  - Thickness
  - Carriageway Width

Inventory Surveys: Culvert

- Structure
  - Type
  - Span
  - Width
  - Height
  - Depth of Slab
- Superstructure - Type
- Substructure - Type
- Foundation
  - Type
  - Construction details
- Wingwall Type
- Railing / Parapet
  - Type
  - Width
- Crash Barrier
- Wearing Course
  - Type
  - Thickness
  - Carriageway Width

Condition Surveys: Roads

- Pavement
  - Rutting: depth, breadth, width and length of rutting, distance from the centre line.
  - Cracking: width and length of cracking, type of cracking (hair cracking, alligator cracking, etc.)
  - Pot Holes: depth, breadth and width of pot hole.
  - Stripping: area of stripping.
  - Length affected by Ravelling.

- Area of Shoving.
- Skid resistance.

➢ Pavement Strength evaluation:
- Deflection.
- Field CBR.

➢ Shoulders:
- Width of shoulder,
- Condition.
- Condition of kerbs.
- Side slopes in case of embankment: condition of slope approximate distance of toe from the edge of the shoulder.

➢ Drainage:
- Type of side drainage
- Width, depth/diameter of side drains, material used for construction, condition.
- Type of cross drainage, condition, material used for construction.
- Adequacy of waterway.

Condition Surveys: Bridges

➢ Superstructure - Slab
- Overall Condition
- Spalling of Concrete
- Exposed reinforcement
- Presence of Cracks
- Vibration

➢ Abutment
- Overall Condition
- Spalling of Concrete
- Exposed reinforcement
- Presence of Cracks

➢ Pier
- Overall Condition
- Spalling of Concrete
- Exposed reinforcement
- Presence of Cracks

➢ Other
- Parapet / Railing
- Footpath
- Wearing Course
- Expansion Joint
- Bearings
- Waterway
- Presence of Scour

- Floor Protection
- Approach Protection

Condition Surveys: Culverts

- Superstructure
  - Overall Condition
  - Spalling of Concrete
  - Exposed reinforcement
  - Presence of Cracks
  - Vibration
- Abutment
  - Overall Condition
  - Spalling of Concrete
  - Exposed reinforcement
  - Presence of Cracks
- Pier
  - Overall Condition
  - Spalling of Concrete
  - Exposed reinforcement
  - Presence of Cracks
- Pipe
  - Overall Condition
  - Headwall
- Other
  - Clogging / Silting
  - Parapet / Railing
  - Waterway
  - Presence of Scour
  - Floor Protection
  - Approach Protection

Traffic and Other Survey Data

- Classified Traffic volume data.
- Origin and destination surveys
- Speed and delay pattern.
- Vehicle Operating Costs
- Costs of Maintenance and New Works

9. POSSIBLE ACTION PLAN

The activities required and responsibility assigned for initial data collection is summarised in Table 9.1, below. Some of the activities could be undertaken simultaneously. Completion of the whole list is essential.

Table 9.1: Action Plan for Re-establishment of Condition and Traffic Surveys

Sl.No	Description of Activities	Months					
		1	2	3	4	5	6
1	Review available data and existing data collection procedures						
2	Assign Data Collection Co-ordinator and assistance						
3	Finalize the Pilot network						
4	Collate all data (available in paper based or electronic format) and put it in structured data tables (in MS Access database)						
5	Collate LRS, Roadway Inventory and Pavement data from Division offices						
6	Finalise LRS parameters for Pilot network						
7	Prepare suitable contract documents for collection of Roughness, Visual Condition, Strength and Traffic data						
8	Determine budgets for data collection						
9	Prepare list of Contractors capabale of carrying out Data Collection surveys						
10	Receive approval to obtain bids fro data collection						
11	Training in Condition Survey Techniques						

10. PRESENTATION TO PROJECT STEERING COMMITTEE

Report No. 34: Report to Re-establish Annual Road and Bridge Condition and Traffic Surveys for Core Network

PWD FOCUS GROUP I

Sri D.V.S. Sarawat	Chief Engineer, UPRNN Lucknow, Chairman
Sri Surendra Kumar	Joint Managing Director, UP State Bridge Corporation, Lucknow
Sri Arun Kumar	EE CD-1, Aligarth
Sri Rajan Mittal	EE PD Saharanpur
Sri Anurag Asthana	EE UPRDA, Lucknow
Sri Navin Kumar	EE Ty. DCU(NH), Lucknow
Sri Anay Kumar Srivastava	AE IDS Cell
Sri Sandeep Saxena	AE IDS Cell
Mr. Anand Prakash	Deputy Team Leader, LEA International
Mr. Satyakam Sahu	Traffic and Transport Engineer

Report No. 34: Report to Re-establish Annual Road and Bridge Condition and Traffic Surveys for Core Network

The principal objective of Re-establishing Annual Road and Bridge Condition and Traffic Surveys is to plan maintenance so that it is based on 'need', i.e. the existing condition of the road or bridge.

Cyclical maintenance plans that are based on recurring maintenance interventions are not cost effective since they are not based on the actual condition of the road.

If a Road Maintenance Management System (RMMS) is to be introduced into the PWD it will enable road maintenance to be prioritised using techno-economic criteria. The annual maintenance budget based on such an approach will be robust and will withstand scrutiny.

However such a system requires annual condition surveys and traffic surveys to be carried out. It is suggested that the cost of these surveys be highlighted separately in the annual maintenance budget.

Report No. 34: Report to Re-establish Annual Road and Bridge Condition and Traffic Surveys for Core Network

Significant time and resources are required for data acquisition. It is imperative that the PWD create a budget for the collection of both inventory and condition data.

Experience of implementing Road Maintenance Management Systems (RMMS) in other countries has shown that a simplified system, using the minimum necessary data, has a reasonable chance of being successfully implemented and of being sustainable.

The following 'types' of data are identified as necessary for an RMMS.

- Location Referencing
- Road Network data
- Road Inventory
- Drainage Inventory
- Road Condition (Roughness and visual surface condition)
- Pavement History
- Pavement Strength
- Traffic (volume, composition, growth rate, axle load, etc.)

Report No. 34: Report to Re-establish Annual Road and Bridge Condition and Traffic Surveys for Core Network

The following 'types' of data are identified as necessary for an RMMS:

- Vehicle Operating Costs
- Cost of Maintenance works undertaken - to provide database for different types of maintenance interventions and respective dates of when work was carried out
- GIS-based base maps

Report No. 34: Report to Re-establish Annual Road and Bridge Condition and Traffic Surveys for Core Network

The following 'types' of data are identified as necessary for an RMMS:

- Bridge Inventory
- Bridge Condition
- Culvert Inventory
- Culvert Condition
- Other Structures (Retaining walls, etc) Inventory
- Other Structures Condition

A more detailed list of data to be collected is given in Section 10 of the Report

LOCATION REFERENCING SYSTEM

To ensure that data collected under different surveys are stored correctly in a database system and can be related and compared, it is important to have a standardised Location Referencing System (LRS) in place. Various process and analyses related to road management require cross-referencing of object and activity, which must be related to roads based on linear as well as spatial referencing methods.

List of Location Reference Points (LRP)

The LRPs could include prominent visual points or objects along a road, such as:

- Start of road (usually a 'virtual' point without a specific identifier)
- Kilometre post
- End of a bridge-deck
- Major road or street intersection
- Division or District border
- Monument or entrance to temple, school, etc.

Road Sections Based on Divisions, Circles, and Zones

Divisions are the basic executive entity in PWD. Hence, it is essential that the road sections within a Division are well identified.

As a follow up to this the road sections within each Circle and Zone will be clearly identified.

IMPLEMENTING A LOCATION REFERENCING SYSTEM

Before commencing data collection, it is preferable to define Nodes, Links and LRP for all the roads in the road network. Data collection based on predefined links and LRPs will reduce the time and resources needed for processing the data to be entered into the referenced database system.

Preliminary identification of these LRS parameters will be undertaken as a desktop exercise, using available maps. The distance between LRPs will be defined based on data available in the MIS database, or in hard-copy records. Once the tentative LRS is defined, it may need to be verified for correctness by Division office, or through site-visit checking.

Out-Sourcing Data Collection

No functioning automatic road survey equipment could be located in PWD.

Current PWD projects are utilising external service providers to carry out the data collection. A similar approach should be followed for collection of network-level planning data.

Quality of Data Collected

It is very important that the necessary quality control procedures (with strict equipment and surveyor calibration requirements) are included in the contract document to ensure that the data provided are reliable.

Collection of Road Inventory Data

With the no specific equipment required, except a simple distance measuring instrument, the roadway inventory data can easily be collected by appropriately trained personnel. Inventory data collection is a one-off process. Once data is available in the system, it should be updated only when there is change in the characteristics of the road network. The inventory data, made available in RIS, can be verified at the time of the visual condition data collection survey.

VISUAL ROAD CONDITION DATA

The *current* visual road condition is a major parameter for assessing the *future* condition of each road segment and for determining the possible maintenance interventions. The *current* road condition should be used to determine a prioritised maintenance budget and programme.

The visual condition survey will be carried out at least once a year, prior to programming the works for the following year. It can be carried out per km section, preferably after the monsoon season, from a slow moving vehicle. However, the final 100 m of each km length will be surveyed on foot to confirm the assessment of the whole km section.

ROAD ROUGHNESS

Road surface ride-quality ('Roughness') is the most important condition parameter influencing road user comfort and, more importantly, vehicle operating costs.

The IRI is a measure of the impact of the road profile on the ride and dynamic response (vertical movements) of a moving vehicle. The IRI is expressed in m/km. A typical range of IRI values is:

Paved roads: 2 to 4 (ideal) - 12 (a failed road)

Unpaved roads: 4 to 10 (ideal) - 24 (a failed road)

PAVEMENT STRENGTH DATA

The structural strength of the pavement is an important parameter for assessing the future performance of a road section. Both ASTHO and HDM-4 procedures use the structural number parameter as a pavement strength variable.

Comparing the pavement strength required for a given traffic loading level with the strength of the existing pavement structure, will allow sections requiring strengthening to be identified. A more detailed study of the strengthening requirement of the road, based on IRC Code 81, will be required, if a particular road is selected for maintenance treatment.

TRAFFIC and OTHER DATA

Traffic data is one of the most important sets of data used for road planning, design and maintenance management. The collection described here is mainly limited to requirements of network level maintenance planning purposes. More detailed data on traffic will be required for pavement or bridge design and transport planning purposes.

PWD has carried out a traffic census in accordance with IRC: 9 -1972, which is a repetitive 7-day counts at pre-selected stations. No definite criteria are laid down for the number of census stations.

Traffic counts are conducted based on the vehicle fleet grouped into the following types:

- Cars, Jeeps, Vans,
- Buses
- Trucks
- Motorcycles and scooters
- Three wheelers
- Animal drawn
- Bicycles

TRAFFIC GROWTH RATES

Traffic growth rate is calculated based on predicted economic growth, analysis of the historic traffic counts and plans for future development of the area. Hence, the same traffic growth rate is used for a sub-network and network for planning purposes.

UNIT COSTS

Unit costs are the basic cost estimate indices of materials, plant and labour and other charges to carry out new construction and maintenance works for roads and bridges. They are normally collected from ongoing and past works by external contractors, but could be extracted from PWD conducted works if such information is recorded.

Without these figures, cost estimates of the proposed work programme will not be possible. These data must be updated annually.

A PILOT IMPLEMENTATION OF DATA COLLECTION

To test the effectiveness of the described data collection procedures and the appropriateness of the collected data for use in an RMMS, it is proposed that a Pilot scheme be put in place on the UP road network. This is not part of the current TA Project.

Based on the findings from the Pilot scheme, any refinement needed to the system can be undertaken before implementing it generally on the whole PWD network. The part of the strategic core network without on-going construction projects is proposed as the source of pilot roads.

ESTABLISHMENT of a ROAD MAINTENANCE MANAGEMENT SYSTEM

One of the components of this Project is the establishment of a Road Maintenance Management System and appropriate Unit.

It is this Unit which will ultimately be responsible for ensuring that the necessary condition and survey data is collected and used to determine a prioritised list of roads for maintenance together with a budget which will be robust enough to withstand scrutiny at the highest level.

Report No. 34: Report to Re-establish Annual Road and Bridge Condition and Traffic Surveys for Core Network

Sl.No	Description of Activities	Months					
		1	2	3	4	5	6
1	Review available data and existing data collection procedures						
2	Assign Data Collection Co-ordinator and assistance						
3	Finalize the Pilot network						
4	Collate all data (available in paper based or electronic format) and put it in structured data tables (in MS Access database)						
5	Collate LRS, Roadway Inventory and Pavement data from Division offices						
6	Finalise LRS parameters for Pilot network						
7	Prepare suitable contract documents for collection of Roughness, Visual Condition, Strength and Traffic data						
8	Determine budgets for data collection						
9	Prepare list of Contractors capabale of carrying out Data Collection surveys						
10	Receive approval to obtain bids fro data collection						
11	Training in Condition Survey Techniques						

Action Plan for the first six months

ANNEXURE 1: LOCATION REFERENCING SYSTEM GUIDELINES

1. BACKGROUND

A standardised Location Referencing System (LRS) should be followed, so that the data are collected and managed in consistent manner. The guidelines included here should be used as basic principles for location referencing for UP PWD road network.

2. NETWORK MODEL

2.1 DEFINITIONS

As shown in **Figure 1**, the UPMMS will use the following definitions for network referencing:

- **Nodes** are used to mark points where traffic or road characteristics change. These include changes in traffic volume or composition, significant changes in geometry, road layout, population centres or administration boundaries. The first step in referencing a road network is to define the nodes. For the UPMMS they will be defined at **major intersections and district boundaries.**
- **Links** are a length of road joining two nodes. Typically, links are assumed to be **homogeneous in terms of traffic**.
- **Location Reference Points:** LRPs are intermediate points between nodes. They are used to define smaller lengths of a link as segments. The km stones are the **LRP** for the Project network. All data will be referenced relative to a node or km stone
- A **segment** is a length of road that is homogeneous in terms of its physical attributes or other features. It may also be defined for convenience, for example by breaking down a long link into more manageable shorter sections. The start and end of a segment is defined with LRPs.
- **Analysis Section:** Analysis sections are created by Dynamic Segmentation based on parameters sensitive to the maintenance works programming and costs. These sections are used for preparing work programme in MMS (with decision-tree or modeling algorithms).
- **Network:** Networks are a collection of sections grouped together for administrative or analysis purposes. These can be represented or modeled in two ways:
  - **Physical Networks:** These comprise the geometric description of roads within a region. They usually contain locational and inventory information, and are represented graphically using two-dimensional maps.
  - **Logical or Administrative Networks:** These are groups of sections within a physical network performing a detailed function. For example, this could be all two-lane roads, all paved roads, etc.

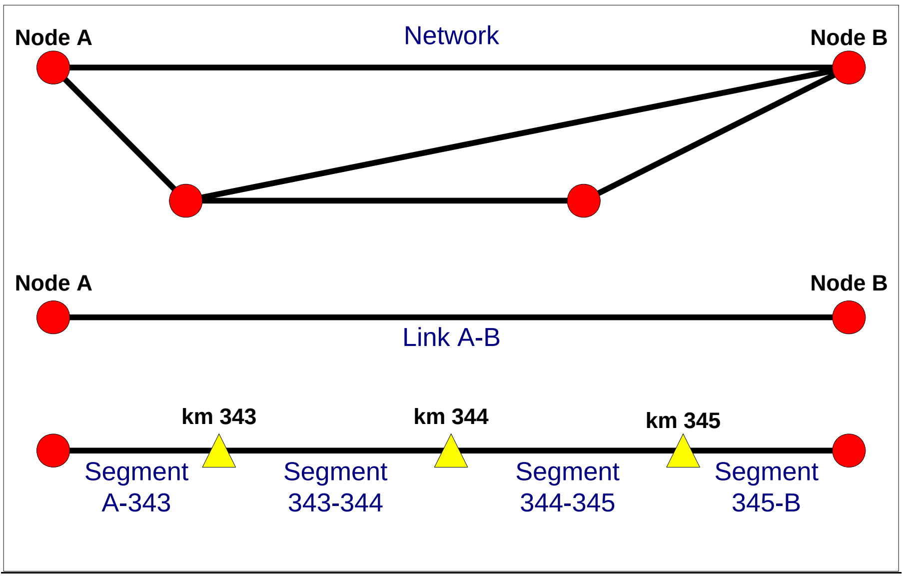


Figure 1: Network Elements

2,2 NAMING CONVENTIONS

The abbreviation for Road Category will be as follows:

- NH – National Highway
- SH - State Highway
- MD - Major District Roads
- OD - Other District Roads
- VR - Village Roads

The naming conventions will be as follows:

- **Node: A** unique five digit number preceded by the letter N
- **Road ID:** The road category and unique number
- **Link ID:** Road_ID followed by ":L"then Start LRP then "-" then End LRP
- **Km Stones:** The kilometer presented as a four digit number preceded by the letter Road_ID and ":K"
- **Junctions:** The kilometer presented as a four digit number preceded by the letter Road_ID and ":J"
- Bridge_ID:
- **Segments:** The road category and number followed by the start and end nodes or km stones

A special convention will be used for divided highways. These will have the suffix /I (for increasing km stone) or /D (for decreasing km stone) included.

Examples of the naming convention are:

Node	SH008_SH002	Node at Junction between NH1 and SH2 (Only 2 major road at the junction considered)
	SH008_K0000	Node at start of NH1 (In case where it does not start from any major junctions)
Road	SH008	
Link	SH008:LJ034A-K0345	Link on SH1 between nodes KM post 1 to KM post 345
	SH008:LK000- K0034	Link on NH1 between nodes KM post 1 to intersection with SH2
LRP **Km Stone**	SH008:K0345	Km Stone 345 of NH1 (If there is more than one same kilometer post add suffix A, B etc.)
LRP **Junction**	SH008:J0345A	The first junction after KM post 345
Segment	SH008:N02351-K0345	Segment on NH8 between node 02351 and km 345
	SH008:SK0358-K0359/D	Segment on NH8 between km 0358 and km 0359 in the decreasing direction (i.e. on the side of the road where the km stones would be decreasing in the direction of travel)
	SH008:SK0358-K0359/I	Segment on NH8 between km 0358 and km 0359 in the increasing direction

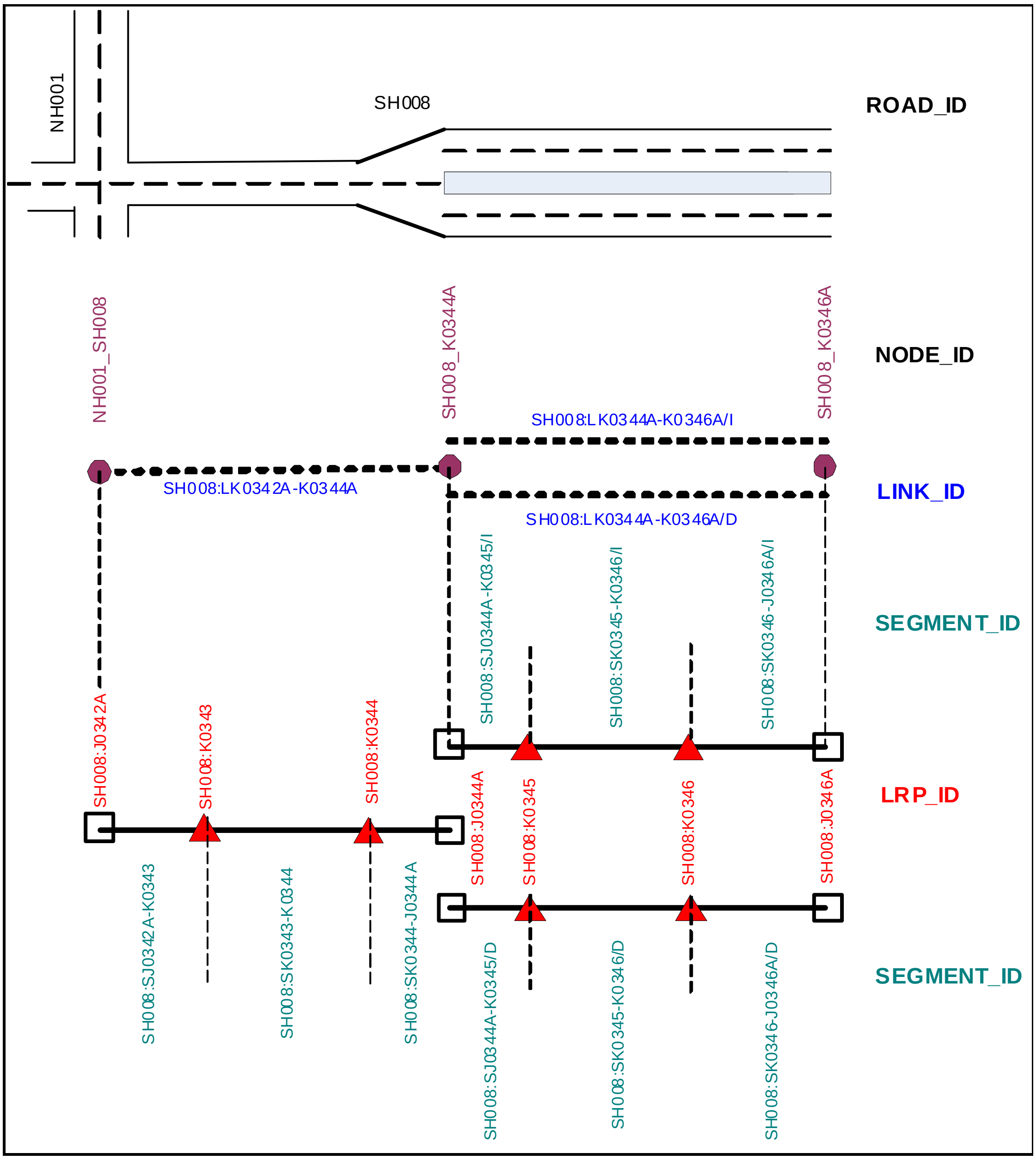


Figure 2: Example of Naming Convention

2.3 INTERCHANGES

Interchanges will be given a unique number, based on their location. This would see each location where there are ramps or interchanges given a single number based on the distance from the nearest km (i.e. the "nominal" distance from start of the highway). This system is not applied to each individual ramp, but to the overall location or interchange.

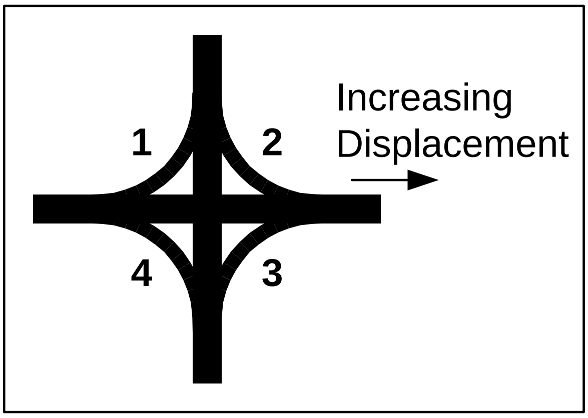
The initial assignment of the unique interchange number will be based on an offset from the nearest km, for example;

- km 232 + 0.24km = interchange 232
- km 232 + 0.88km = interchange 233

2.4 RAMPS

Ramps are treated as separate links, and assigned a unique number. Nodes are used at the start and end of each ramp. Individual ramps will be numbered by starting at the first ramp junction encountered in the increasing kilometre stone direction on the lower highway number and then to number in a clockwise manner. The number has nothing to do with the ramp direction or function; it is just a unique code. This is shown in some examples below.

- If a ramp is constructed at a later stage it would be given the next higher number.
- When two directions travel on the same ramp it should be treated as two ramps.
- All ramps will have increasing route positions in the direction of travel.



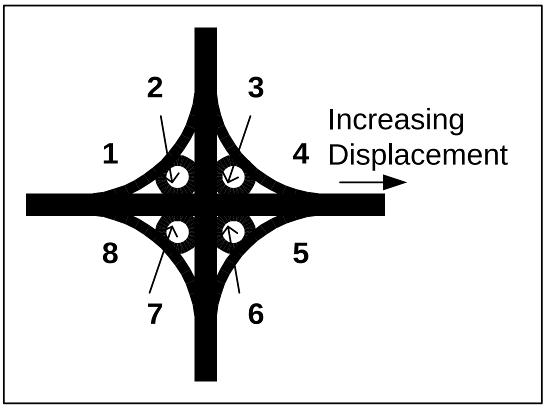


Figure 3: Examples of Ramp Numbering

The data to be stored against each ramp includes:

- Link_ID
- Interchange_ID
- Ramp_ID (i.e. ramp number)
- Ramp_Type (i.e. type of ramp ON/OFF)

In other words, ramps are an attribute of a link.

The following is an example of how a ramp would be identified:

Interchange_ID	NH008:I0205	Interchange number 205 (near km 205)
Ramp_ID	NH008:R0205_1	Ramp number
Ramp_Type	OFF	Ramp type (OFF ramp or ON ramp)

2.6 ROUNDABOUTS

In the same way that ramps are treated as separate roads, the same applies to “large” roundabouts (traffic circles). This is necessary because of two problems that can arise with roundabouts. The first relates to the length discrepancy between increasing and decreasing measurements along a route. As shown in **Figure 4**, the measured distance from A to B varies around the roundabout dependant on the direction of travel. The second relates to the extra areas (X and Y) of the roundabout which, if not treated as a separate road, are not referenced and therefore cannot have data stored against them.

For large roundabouts (> 150 m diameter) the roundabout itself it defined as a link. It has the same start and end node. To prevent double counting of distances along the roundabout, the travel in the main direction should be terminated with nodes at the entry and exit of the roundabout, with a distance of 0 used to create a dummy link between these nodes.

As with ramps, roundabouts are an attribute of a link.

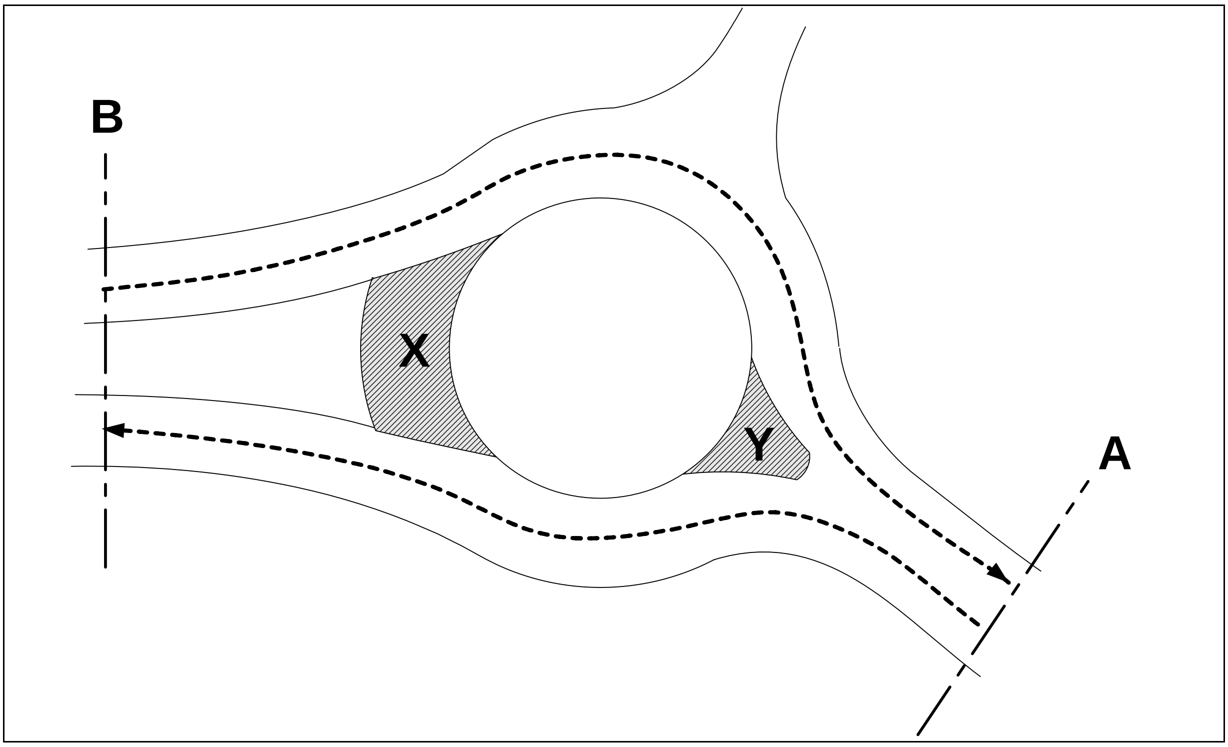


Figure 4: Referencing Issues at Roundabouts

The roundabout ID is a unique number based on the nominal kilometreage of the roundabout. The following is an example of how a large roundabout would be identified:

Roundabout_ID	NH008:R0217	Roundabout number (near km 217) (Add suffix A, B, etc. if more than 1 round about in the same KM)

3. DATA REFERENCING

3.1 PRINCIPLE

Data can be referenced in the UPMMS/PMS using one of three different referencing objects:

- **Point:** The data exist at a single location, e.g. a traffic sign.
- **Section:** The data apply over a section (or a segment or a link) of road, e.g. roughness which has been measured over 1000 m intervals. These data have a start and end location.
- **Independent:** The data are not related to a road, e.g. a seawall, an HDM-4 calibration factor, etc.

This principle is detailed below in case of road data (or road attributes) and bridges and culverts.

3.2 ROAD ATTRIBUTES

Road attributes (or data) can be **point** or section. The same basic approach is used for all data. The location reference consists of:

- **ID**. A unique identifier, such as the link;
- **Start Reference Point**. The reference point where the data referencing starts from, such as a Node or km post number;
- **Location from Start Reference Point**. The distance from the reference point where the measurements start (m). In the case of a point event this is the only reference.
- **End Reference Point**. The reference point where the data referencing starts from, such as a Node or LRP number (only if the measurement is over an interval).
- **Location from End Reference Point**. The distance from the reference point where the measurements ends. (Only if the measurement is over an interval).

3.3 BRIDGES AND CULVERTS

The following data are recorded as referencing data for each bridge:

- **Link_ID.**
- **Bridge_ID**. A unique identifier
- **Bridge_Num**
- **Bridge_Name**
- **Start Reference Point**. The reference point where the data referencing starts from, such as a Node or km post number;
- **Location from Start Reference Point**. The distance from the reference point where the measurements start (m). In the case of a point event this is the only reference.

The bridge number is a unique number which can be used to identify the bridges. Minor bridges and culverts are identified by their location on the road. For example, 157/1 and 157/2 would be the first and second drainage structures occurring between km 156 and 157 (not as would be intuitively expected as the structures after km 157). If additional structures are installed, the numbering will be altered.

ANNEXURE 2: DATA TABLES - EXAMPLES

LU_ClimateZone

Code	Desc	Moisture	Temp
1	WetZone	Humid	Tropical
2	DryZone	Semi-arid	Tropical

LU_Division

DIV_ID	DIV_NAME	DIS_ID	Prov_Num
110	C.M.C. Limits	11	1

LU_DrnCnd

Code	Desc
1	Free Flowing
2	Blocked
3	Scouring
4	Severe Damage

LU_DrnType

Code	Desc
1	Nil Drain
2	Lined
3	Unlined
4	Not Reqd

LU_GeometryClass

Code	Desc	RF	Num_RF	HCurv
F	Bendy and generally level	3	2	50
R	Bendy and severely undulating	20	3	150
M	Winding and severely undulating	40	4	500

LU_GrvDepth

Code	Desc
1	0 to 50 mm
2	50 to 100 mm
3	> 100 mm

LU_LRP

Code	Desc
NOD	Node
KMP	Kilometre Post
INT	Intersection/Junction
BRG	Bridge

LU_PaveType

Code	Desc	Abrv
1	Paved	P
2	UnPaved	U
3	Earthen	E
4	Rigid	R

LU_RoadClass

Road_Class	Desc
NH	National Highway
SH	State Highway
MD	Major District Road
OD	Other District Road
VR	Village Road

LU_RoadEnv

Code	Description	Traffic_Flow
CU	Central Urban	Commuter
OU	Outer Urban	Inter-urban
RU	Rural	Free-Flow

LU_RoadWidthClass

Code	Desc	Min	Max	HDM_SpeedFlow	HDM_CwayWidth
S	Single Lane	0	4	Single Lane	3.5
I	Intermediate Lane	4.01	5.5	Intermediate Lane	4.5
D	Double Lane	5.51	9	Double Lane	7
M	Multiple Lane	9.01	30	Multiple Lane	15.2

LU_RoughClass

Code	Desc	SurfType	Min	Max	ReprValue	Desc_Manual
1	Excellent	A	0	3	3	Smooth
2	Good	A	3.000001	5.5	4.5	ReasonablySmooth
3	Fair	A	5.500001	7	6	MediumRough
4	Poor	A	7.000001	10	8	Rough
5	Bad	A	10	30	11	VeryRough

LU_ShldType

Code	Desc
E	Earthen
P	Paved
U	UnPaved

LU_Terrain

TERRAIN_ID	TERRAIN_DESC
F	Flat
M	Mountainous
R	Rolling

LU_TrafficClass

Code	Desc	Min	Max	ReprValue
1	VeryLow	1	750	500
2	Low	751	2500	1500
3	Medium	2501	10000	7000
4	High	10001	20000	15000
5	VeryHigh	20001	100000	25000

LU_SurfType

Code	AC	GR	CO	BL	DBST	PM	GRP	SD
Desc	Asphalt Concrete	Gravel	Cement Concrete	Block Pave	DBST	PM	Primed	SBCT
PaveType	P	U	R	R	P	P	U	P
SurfType	A	G	C	B	S	P	T	S

LU_HDM_PavType

Code	Definition
AMGB	Asphalt mix on gravel base
AMAB	Asphalt mix on asphalt base (i.e. dense bitumen macadam)
AMAP	Asphalt mix on asphalt pavement (i.e. as a result of successive thin wearing course on gravel base)
STGB	Surface treatment on gravel base
STAB	Surface treatment on asphalt base (i.e. dense bitumen macadam)
STAP	Surface treatment on asphalt pavement (i.e. as a result of successive thin wearing course on gravel base)

LU_BMS_StrucType

Code	Description
B	Bridge
F	Ford
C	Major Culvert

LU_BMS_ConstType

Code	Description
ARCH	Arch
BALY	Bailey
BMSL	Beam and slab
GRDR	Girder
LOG	Log
NA	N/A
OTHR	Other
PRTL	Portal
SSPN	Suspension
TRSS	Truss

LU_BMS_ObsType

Code	Description
RIVR	River
RAIL	Railway
ROAD	Road

ANNEXURE 3: LOCATION REFERENCING SYSTEM GUIDELINES

VISUAL CONDITION RATING FOR BLACK TOP ROAD (UPMMS)

(Form used on Site)

Form PMS-001

Circle	…	**Road**	**Code**	…	**Node/**	**From**	N01252	**Date of Inspection**:		**Month**	01
Division	…	**Link**	**ID**	…	**Km**	**To**	N01253	**Year**	2004	**Day**	20
			Name								

Black top Road (% in length)

From	To	Failed Sections				Cracking				Ravelling				Potholes				Rutting				Edge break				Drainage				Remarks
		0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	
N01252	K0001	X			x					x					x				x			x				x				
K0001	K0002		x			x						x				x			x				x					x		
K0002	K0003		x			x						x				x			x				x					x		
K0003	K0004		x			x						x				x			x				x					x		
K0004	K0005		x			x						x				x			x				x					x		
…	…																													
K0025	N01253						x	x				x					x		x					x				x		

VISUAL CONDITION RATING FOR BLACK TOP ROAD (UPMMS)

(Form used on Site)

Form PMS-002											
Circle	…	**Road**	**Code**	…	**Node/**	**From**	N01252	**Date of Inspection:**		**Month**	01
Division	…	**Link**	**ID**	…	**Km**	**To**	N01253	**Year**	2004	**Day**	20
			Name								

Gravel Roads (% in length)

From	To	Need for Reconstruction				Need for Minor Shaping				Need for Regravelling				Roughness				Remarks
		0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	
N01252	K0001	**x**					**x**				**x**							
K0001	K0002		**x**					**x**			**x**							
K0002	K0003		**x**					**x**			**x**							
K0003	K0004		**x**					**x**			**x**							
K0004	K0005		**x**					**x**			**x**							
…	…																	
K0025	N01253			**x**					**x**		**x**							

* Severity is defined in % of length. Accordingly, Severity "High" for Reconstruction…

AND Minor Shaping AND Regravelling for the same row is not consistent.

ANNEXURE 4: ESTIMATED COST FOR DATA COLLECTION

The cost for data collection to be undertaken using external service provider is summarized in **Table 1**.

SN	Activity	Unit	Quantity	Rate in Rs	Amount in Rs
1. Roadway Inventory and Visual Surface Distress Data Collection					
	Paved Road in 1000 m interval	KM	7000	a200	1,400,000.00
	Unpaved Road 1000 m interval	KM	1	200	200.00
2. Roughness Data collection using Bump Integrator					
	Reading in 100 m interval	Lane KM	7000	300	2,100,000.00
3. Benkelman Beam Survey					
	2 readings in 1 KM	KM	1500	1000	1,500,000.00
4. Testpit Data Collection					
	Testpit in AC road (I in 5 KM)	Each	300	900	270,000.00
5. Centreline GPS Data Collection and shape file preparation[1]					
	10 m interval	KM	7000	200	1,400,000.00
6. Traffic volume data collection at traffic station					
	3 Day count	Each	1000	900	900,000.00
7. Simplified Bridge Condition Assessment					
	Culvert and small bridge	Each	7000	100	700,000.00
	MediumBridge	Each	500	300	150,000.00
	Large Bidge	Each	500	500	250,000.00
	TOTAL				**8,670,200.00**

Note: 1/ Considering the data collection will be conducted together with other survey eg. Roughness