International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 01, January-2018

Situation Analysis of Rural Road Maintenance Management System in Madhya Pradesh- A Case Study in Jabalpur District based on Interview and Questionnaires

*Patel Ghanshyam[1], Dr Yadav Shalini[2], Dr Khatri Rajiv[3] ,

*1 Research Scholar, Ph.D., Department of Civil Engineering, AISECT University, Bhopal 462051, India
2 HoD, Civil Engineering Department, AISECT University Bhopal 462051(MP) , India.
3 Director, Global Nature Care Sangathan's Group of Institutions, Faculty of Engineering & Management Jabalpur 482001, India

ABSTRACT:- ***Construction of rural roads brings multifaceted benefits to the rural areas by way of increase in agricultural production and the size of market, better prices for agriculture produce, reduction in transport cost and the creation of off-farm employment opportunities. They also provide access to medical and educational facilities. Provision of rural roads is an effective element of a poverty alleviation strategy. Rural roads form a large share of the total road network in India. If these roads are not maintained, the benefits envisaged disappear. Keeping them in a serviceable condition is crucial to the agricultural growth and affording means of access to millions of rural people to social facilities such as health and education. Subsequent to a series of regional level workshops organized by the Ministry of Rural Development, and a series of overview studies supported by the World Bank on rural road maintenance in a few states, several areas for improvements in the delivery of maintenance have been identified. These include resource mobilization, maintenance planning, technology, implementation, monitoring and capacity building of local workers. Accordingly to understand the present status, a detailed situation analysis of rural road maintenance in Madhya Pradesh by field work has been carried out in 28 Roads, four roads in each seven blocks of Jabalpur districts based on interview and Questionnaires' in the state of Madhya Pradesh. The finding of this study will be highly useful to preserve the benefits of huge rural road assets created recently in India.***

KEY WORDS:-VI=Very Important, I=Important, A=Average, NI=Not Important, LI=Least Important, StA= Strongly Agreed, A = Agreed, SlA = Slightly Agreed, DA = Disagreed, SDA = Strongly Disagreed, StA = Strongly Agreed, A = Agreed, SlA = Slightly Agreed, DA = Disagreed, SDA = Strongly Disagreed.

1INTRODUCTION

To understand the problems of road maintenance a study was conducted on Four Roads in each Block of Jabalpur district of Madhya Pradesh. The district comprises of seven blocks namely –

1. Jabalpur 2. Kundam 3. Majholi
4. Panagar 5. Patan 6. Shahpura
7. Sihora.

Road map route plan of Jabalpur District has been prepared and Road Code/Symbol has been given to portion of four roads in each block so as to ease the work, such as, JJR1 where J for Jabalpur District., J for Jabalpur Block, R1-R2-R3-R4 for road numbers 1,2,3,4; similarly for other Blocks as K for Kundam Block, M for Majholi Block, P for Panagar Block, PA for Patan Block, S for Sahapura Block and SI for Sihora Block.So the whole of the study area has been identified and defined by these road codes. The portions of 28 number of roads selected for study, are listed below with code.

Jabalpur Block

(1) JJR1 (L051) RDS to Hinotia (3.50 Km)
(2) JJR2 NH 12 to Balhara (4.10 Km)
(3) JJR3 Bargi Dam Road to Rewa (4.45 Km)
(4) JJR4 Bargi to Rangajhori (5.20 Km)

Kundam Block

(5) JKR1 SH 22 to Kalyanpur (15.65 Km)
(6) JKR2 Kundam to Salaiya Road (0.90 Km)
(7) JKR3 SH 22 (Km 62/10)To Sahadra (3.70 Km)
(8) JKR4 Jhiriya to Jaitpuri (3.40 Km)

Majholi Block

(9) JMR1Majholi to Suhajani (6.65 Km)
(10) JMR2 Abhana Road To Umardha (3.26 Km)
(11) JMR3 T04 to Umaria (3.175 Km)
(12) JMR4 Darshani to Gurji (3.50 Km)

Panagar Block

(13) JPR1 Dumna Road to Gadheri (3.60 Km)
(14) JPR2 SH 37 To Mangela (2.80 Km)
(15) JPR3 NH 7 To Imlai (2.10 Km)
(16) JPR4 ODR to Urduakala (3.92 Km)

Patan Block

(17) JPAR1 SH37 to Kankarkheda (2.15 Km)
(18) JPAR2 MDR to Luhari (1.50 Km)
(19) JPAR3 ODR to Rimjha (2.30 Km)
(20) JPAR4 ODR to Thana (1.45 Km)

Shahpura Block

(21) JSR1Tilwara Chargawa Road to Bagari (3.20 Km)
(22) JSR2 Jabalpur Chargawa Road to Sunwara (2.40 Km)
(23) JSR3 NH- 12 to Sunacher (4.30 Km)
(24) JSR4 NH12 to Basedi (2.00 Km)

Sihora Block

(25) JSIR1 NH 7 To Hyrdenagar (4.91 Km)
(26) JSIR2 NH7 to Katra Khamariya (6.83 Km)
(27) JSIR3Pipariya to Marha (p) (3.00 Km)
(28) JSIR4SihoraSilondi Road to Bhandra (4.40 Km)

2. CASE STUDY (Data Collection and Extraction)

To obtain the data for the Situation Analysis, interviews and questionnaires have been planned with the Officers of Works Department, Villagers and Sarpanch of each Roads. All the relevant information required is collected from the Road Maintenance Branch of Works Department, Villagers and Sarpanch and locals so as to understand the current procedure for Road Maintenance Management System, the problems on road maintenance management system and the basic approach to improve the road maintenance management system at the Works Department. The interviews have been conducted with the officers of Work Department, Villagers and Sarpanch which attached at the Road Maintenance Branch. Most officers have the experience of more than three years in this field which shows their expertise and understanding of the problems and solutions related to road maintenance and management. The aim of the interviews is to attain the first hand information on the present practice of Road Maintenance Management System at Works Department.

Questionnaire prepared consisted of a set of standard questions, divided into three sections, which include (1) The factors that are important to be considered in Road Maintenance Management System, (2) Problems of Road Maintenance Management System and (3) Basic approach in improving the Road Maintenance Management System.

Considering all the above factors in mind, a Questionnaire form has been developed with standard set of questions as a model questions for Analysis. Responses from about ten number of user/stack holders have been collected for each of

the 28 roads. To facilitate the respondents to understand the question better, these questions have also been translated in Regional Language, Hindi. These Questionnaires are represented in Q-1, Q-2, Q-3 andQ-4 below.

Q-1 QUESTIONNAIRE Part I iz'ukoyh Hkkx 1	
Name of RoadjksM dk uke **:- …….**	
• This research is mainly conducted for academic purpose only. ;g 'kks/k dsoYk vdknfed m+)s';ksa ds fy, gh gSA	
• All source and information and data obtained are deemed to be private and confidential. izkIr lHkh lzksr] lwpuk vkSj MsVk dks fuft vkSj xksiuh; ekuk tkosxkA	
• The questionnaire contains of Part I, Part II, Part III, and Part IV. iz'ukoyh esa Hkkx 1] Hkkx 2] Hkkx 3 vkSj Hkkx prqFkZ 'kkfey gSaA Kindly complete the entire question.d`i;k lHkh iz'uks dks iwjk djsaA	
PART I : RESPONDENT BACKGROUNDmRrjnk;h dh i`"BHkwfeA	
1	Respondent's Name mRrjnkf;Ro dk uke :-_____ (optional),sfPNd
2	Address irk :-_____ (optional),sfPNd
3	Contact Number laidZ :-_____ (optional) ,sfPNd
4	Designation in :-_____
5	Experience vuqHko :-_____
6	Level of Academic 'kS{kf.kd Lrj :-_____

Q-2 QUESTIONNAIRE Part IIiz'ukoyh Hkkx 2						
Name of RoadjksM dk uke **:- …….**						
PART II : ROAD CONDITION						
lM+d dh fLFkfr						
Which of the following factors are important in road maintenance ? **Please rate accordingly by ticking** √ jksM esUVusUl ds fy, fuEu dkjdksa es ls dkSu lk dkjd egRoiw.kZ gSAmlds fglkc ls √ vafdr djsa A **1. Very Important (VI) 2. Important (I) 3. Average (A) 4. Not Important (NI) 5. Least Important (LI)** 1 cgqr egRoiw.kZ 2 egRoiw.kZ 3 vkSlr 4 egRoiw.kZ ughs 5 lcls de egRoiw.kZ						
No	**Factors**	**VI**	**I**	**A**	**NI**	**LI**
7	Quality of Work dk;Z dh xq.koRrk	1	2	3	4	5
8	Required Cost vko';d ykxr	1	2	3	4	5
9	Required Period vko';d vof/k	1	2	3	4	5
10	Quality of Design fMtkbZu dh xq.koRrk	1	2	3	4	5
11	Working Load dk;ZdkHkkj	1	2	3	4	5
12	Workers' Skill Jfedksa dh dq'kyrk	1	2	3	4	5
13	Data of Inventory vkd.kksa dh lwph	1	2	3	4	5
14	Database System Lwpuk dk lewg	1	2	3	4	5

Q-3 QUESTIONNAIRE Part IIIiz'ukoyh Hkkx 3

Name of Road jksM dk uke **:- …….**

PART III : PROBLEMS IN ROAD MAINTENANCE MANAGEMENT

lM+d jjojjoko izca/ku esa leL;k,sa

What are the most problems occur during the implementation of road maintenance management system ? Please rate accordingly by ticking √

lM+d jjojjoko iz.kkyh ds dk;kZUo;u ds nkSjku lcls vf/kd dkSu lh leL;k,sa vkrh gSaA mlds fglkc ls √ vafdr djsa A

1. Strongly Agree (StA) 2. Agree (A) 3. Slightly Agree (SlA) 4. Disagree (DA) 5. Strongly Disagree (SDA)

1 iw.kZ :Ik ls lger 2 lger 3 vkaf'kd lger 4 vlger 5 iw.kZ :Ik ls vlger

No	List of Problems	StA	A	SlA	DA	SDA
15	Funds for the road maintenance lM+d ds jjojjoko ds fy, /ku	1	2	3	4	5
16	Design stage fMtkbZu Pkj.k	1	2	3	4	5
17	Privatisation of road maintenance lM+d jjojjoko dk futhdj.k	1	2	3	4	5
18	Medium of Communication Lapkj dk ek/;e	1	2	3	4	5
19	Specification or manual procedure Specification esU;y izfd;k	1	2	3	4	5
20	Less training for the staff deZpkfj;ksa ds fy, de izf'k{k.k	1	2	3	4	5
21	Data of inventory vkd.kksa dh lwph	1	2	3	4	5
22	Data input and validation MsVk buiqV vkSj ekU;rk	1	2	3	4	5

Q-4 QUESTIONNAIRE Part IViz'ukoyh Hkkx 4

Name of Road jksM dk uke **:- …….**

PART IV : IMPROVING THE ROAD MAINTENANCE MANAGEMENT SYSTEM

lM+d jjojjoko izca/ku iz.kkyh esa lq/kkj

What are the basic approach should be built on by Department to improve the present Road Maintenance Management system? Please rate accordingly by ticking √

orZeku es py jgs lM+d jjojjoko izca/ku iz.kkyh dks lq/kkjus ds fy, foHkkx nwokjk D;k cqfu;knh n`f"Vdks.k cukuk pkfg,A mlds fglkc ls √ vafdr djsa A

1. Strongly Agree (StA) 2. Agree (A) 3. Slightly Agree (SlA) 4. Disagree (DA) 5. Strongly Disagree (SDA)

1 iw.kZ :Ik ls lger 2 lger 3 vkaf'kd lger 4 vlger 5 iw.kZ :Ik ls vlger

No	List of Approaches	StA	A	SlA	DA	SDA
23	Initial study and general survey izkjafHkd v/;;u vkSj tujy losZ{k.k	1	2	3	4	5
24	Standardize the basic system or methodology Ekudkuqlkj cqfu;knh iz.kkyh ;k i)fr	1	2	3	4	5
25	Training for fully understanding of road maintenance lM+d jjojjoko ds fy, iwjh rjg ls le>us ds fy, izf'k{k.k	1	2	3	4	5

26	Identify the maintenance technology and methods lM+d jjojjoko iz;ksx dh igpku ,oa i)fr	1	2	3	4	5
27	Planning for the funds lM+d jjojjoko ds fy, /ku dh ;kstuk	1	2	3	4	5
28	Awareness the design stages lMd jjojjoko esa fMtkbZu pj.kksa esa tkx:drk	1	2	3	4	5
29	Standardized data collection lM+d jjojjoko es ekudhd`r MsVk laxzg	1	2	3	4	5
30	Monitoring the works carried out by concessioners Concessioners n`okjk fd;s x;s dk;Z dh fuxjkuh	1	2	3	4	5

After conducting a Questionnaire survey, total number of responses in favour of each case for all individual questions has been calculated and tabulated.

The information obtained from the questionnaire survey has been analyzed and the average index has been calculated by using formula, as under – Average Index = $\sum \mathbf{a_i x_i} / \sum \mathbf{x_i}$

Where, $\mathbf{a_i}$ = constant that represent the weight of i,

$\mathbf{x_i}$ = variables that represent the respondent

i represent frequency of observations;

i= 1,2,3,4,5.

2.1 ANALYSIS OF QUESTIONNNARIES Q-2: ROAD CONDITION

The data obtained for the questioners corresponding to "Q-2" have been tabulated in table T-1. The frequencies for the best ranked and the least ranked factors which described the importance of Road Maintenance Management System with respect to Road Condition have been derived from the responses of respondents. The factors which are important to be considered in Road Maintenance Management System are listed as eight factors. The most important factors with highest rank having minimum average index 1.59 in Road Maintenance Management System are 'Quality of Work' whilst the least ranked having maximum average index 2.86 is the 'Data of Inventory'.

Table T-1 Road Condition

No	Factors	Very Important	Important	Average	Not Important	Least Important	$\sum x_i$	$\sum a_i x_i$	Average Index $\sum a_i x_i / \sum x_i$	Scale
		VI	I	A	NI	LI				
		1	2	3	4	5				
7	Quality of Work	153	100	20	3	4	280	445	1.59	VI
8	Required Cost	120	140	10	6	4	280	474	1.69	VI
9	Required Period	70	160	40	8	2	280	552	1.97	I
10	Quality of Design	30	159	80	10	1	280	633	2.26	I
11	Working Load	10	160	100	7	3	280	673	2.40	I
12	Workers' Skill	20	120	130	2	8	280	698	2.49	I
13	Data of Inventory	2	80	160	30	8	280	802	2.86	A
14	Database System	1	110	160	3	6	280	743	2.65	A

VI = Very Important, I = Important, A = Average, NI = Not Important, LI = Least Important

To determine the important level of related personnel on maintenance management system, average index method with five different scales is used. The scales are shown below:

1 = 'Very Important' 1.00 ≤Average Index≥ 1.80,
2 = 'Important' 1.80 < Average Index > 2.60,
3 = 'Average' 2.60 < Average Index > 3.40,
4 = 'Not Important' 3.40 < Average Index > 4.20,
5 = 'Least Important' 4.20 < Average Index > 5.00.

From the analysis, the factors which are in "Very Important" category are 'Quality of Work' and 'Required Cost' while the factors which are in important category have been observed to be the 'Required Period', 'Quality of Design', 'Working Load' and 'Workers' Skill'.

The factors 'Data of Inventory' and 'Database System' are observed to be in "Average" category.

In Road Maintenance Management System practice, 'Quality of Work' is most important because the public can judge the road maintenance based on the 'Quality of Work'. When there are more complaints on road maintenance it shows that the Road Maintenance Management System was weak. So, the management should take this factor as the most important in Road Maintenance Management System. Table T-1 shows that the least important factor is Data of Inventory. In actual practice, 'Data of Inventory' was also important in Road Maintenance Management System. This data of inventory was important because from this data, the road maintenance can be evaluated effectively to make sure the maintenances are in order.

2.2 ANALYSIS OF QUESTIONNNARIES Q-3: PROBLEMS IN ROAD MAINTENANCE MANAGEMENT

Problems that occur during the implementation of Road Maintenance Management System need to define by the Public Work Department for improving the current Road Maintenance Management System. This analysis was conducted on the data gathered through interviews and questionnaires.

From these the major problems that occur during the process of Road Maintenance Management System have been observed to be:

i. Budget: Most critical factor in road maintenance works. The Public Works Department need to do prioritization for this for road maintenance.
ii. Project Delivery: Most of the project which deliver to the Branch of Maintenance and Facilities do not comply the acceptance criteria.
iii. Data of Road under Maintenance: the data has been observed to be not accurate and also there have been problems to keep the data in systematic manner.
iv. The departments do not have Standard Manual in Road Maintenance.
v. The departments do not have trained staff.

From the data gathered using questionnaires, the frequencies for the most and the least ranked problems during the implementation of Road Maintenance Management System are derived from the respondents' feedback. The analysis was rigorously done based on eight major problems which listed in T-2. Most respondent agreed that problem in Road Maintenance Management System is 'Fund for the Maintenance' with highest rank having minimum average index 1.70 whilst the least respondent agreed is 'Less Training for the Staff' with lowest rank having maximum average index 3.21.Table T-2showsthat 'Fund for the Maintenance' and 'Design Stage' is in "Strongly Agreed" category, whilst 'Privatization of Road Maintenance', 'Medium of Communication' and 'Specifications or Manual Procedure' are in "Agreed" category. There are three problems fall in the category of "Slightly Agree", these problems are 'Less Training for the Staff' follow by 'Data of Inventory' and lastly 'Data Input and Validation'. As such the Public Works Department need to arrange the funds for the maintenance so that the maintenance works do not get delayed due to availability of fund and the minor problems do not become a major repairing and maintenance problem.

Table T-2 Problemsin Road Maintenance Management

No	List of Problem	Strongly agreed	Agreed	Slightly Agreed	Disagreed	Strongly Disagreed	$\sum x_i$	$\sum a_i x_i$	Average Index $\sum a_i x_i$ / $\sum x_i$	Scale
		StA	A	SlA	DA	SDA				
		1	2	3	4	5				
15	Funds for the Road Maintenance	140	89	48	1	2	280	476	1.70	StA
16	Design Stage	80	180	10	8	2	280	512	1.83	StA
17	Privatization of Road Maintenance	120	70	71	10	9	280	558	1.99	A
18	Medium of Communication	10	138	127	2	3	280	690	2.46	A
19	Specification or Manual Procedure	10	165	100	3	2	280	662	2.36	A
20	Less Training for the Staff	2	78	110	40	50	280	898	3.21	SlA
21	Data of Inventory	3	105	167	3	2	280	736	2.63	SlA
22	Data Input & Validation	4	101	160	6	9	280	755	2.70	SlA

StA = Strongly Agreed, A = Agreed, SlA = Slightly Agreed, DA = Disagreed, SDA = Strongly Disagreed

To determine the important level of related personnel on maintenance management system, average index method with five different scales is used. The scales are shown below:

1 = 'Strongly Agreed' 1.00 < Average Index > 1.80
2 = 'Agreed' 1.80 < Average Index > 2.60
3 = 'Slightly Agreed' 2.60 < Average Index > 3.40
4 = 'Disagreed' 3.40 < Average Index > 4.20
5 = 'Strongly Disagreed' 4.20 < Average Index > 5.00

While the respondent least agreed with the problem on
Road Maintenance Management System due to lack of training to the staff. However, the Public Works Department needs to provide training for their concerned staff, from time to time, so as to acquaint them with the latest developments in the road maintenance and management system.

2.3 ANALYSIS OF QUESTIONNNARIES Q-4: IMPROVING THE ROAD MAINTENANCE MANAGEMENT SYSTEM

Each system has its strength and weaknesses. From the present study, we defined a few problems in Road Maintenance Management System at Public Works Department. The basic approach for improving the current Road Maintenance Management System is shown in Table T-3. The analysis was conducted on the data collected during the study and it is found that there are two basic approaches for improving the Road Maintenance Management System, as (1) Systematic database storage either for the hard copy or soft copy. The systematic database storage information is required when involving the road maintenance ; and

(2) Monitoring the works carried out by Concessionaire

From the data gathered using questionnaires, frequencies of highest and lowest ranked for basic approach for improving the current Road Maintenance Management System are derived from the respondents' feedback. The highest ranked for basic approach is 'Initial Study and General Survey' having minimum average index 1.58 whilst the lowest ranked is 'Monitoring the Works Carried Out by Concessionaire' having maximum average index 3.06.

Table T-3 Basic Approach for Improving Road Maintenance Management System

No	List of Approaches	Strongly agreed	Agreed	Slightly Agreed	Disagreed	Strongly Disagreed	$\sum x_i$	$\sum a_i x_i$	Average Index $\sum a_i x_i / \sum x_i$	Scale
		StA	A	SlA	DA	SDA				
		1	2	3	4	5				
23	Initial Study & General Study	164	80	30	2	4	280	442	1.58	StA
24	Standardize the Basic System or Methodology	100	150	4	10	16	280	532	1.90	A
25	Training for Understanding of Road Maintenance	120	100	20	10	30	280	570	2.04	A
26	Use of Maintenance Technology & Method	20	210	40	6	4	280	604	2.16	A
27	Planning for the Funds	20	130	120	2	8	280	688	2.46	A
28	Awareness at Design Stage	10	140	120	8	2	280	692	2.47	A
29	Standardize Data Collection	10	147	120	2	1	280	677	2.42	A
30	Monitoring the works carried out by Concessionaire	3	70	150	20	37	280	858	3.06	SlA

StA = Strongly Agreed, A = Agreed, SlA = Slightly Agreed, DA = Disagreed, SDA = Strongly Disagreed

To determine the important level of related personnel on maintenance management system, average index method with five different scales is used. The scales are shown below:

1 = 'Strongly Agreed' 1.00 < Average Index > 1.80
2 = 'Agreed' 1.80 < Average Index > 2.60
3 = 'Slightly Agreed' 2.60 < Average Index > 3.40
4 = 'Disagreed' 3.40 < Average Index > 4.20
5 = 'Strongly Disagreed' 4.20 < Average Index > 5.00

From the Table T-3shows that the approach 'Initial Study & General Survey' falls in the category of 'Strongly Agreed' and the other basic approach fall in respectively the category of "Agree", these approaches include, 'Standardize the Basic System or Methodology', 'Training for Understanding of Road Maintenance', 'Use Maintenance Technology and Methods' followed by 'Planning for the Funds' and 'Awareness at Design Stages' along with 'Standardize Data Collection'. Only one approaches fall in the category of "Slightly Agree" that is 'Monitoring of works Carried out by Concessionaire'.

All the maintenance for the road work was privatized for 5 years within construction and 5 years after construction. From the questionnaires, 'Monitoring of Works Carried Out by the Concessionaire' was needed to make sure the maintenance work was done appropriately. Work Departments can improve the ways of monitoring or supervision by increasing the numbers of audit.

The approach of 'Monitoring of Works Carried out by Concessionaire' which obtain the lowest rank with maximum average index by the respondents shows that the Branch of Road Maintenance and Facilities not involving in monitoring the work. In real practice at Work Department, initial study was done by Highway Department. However, cooperation between these two branches can avoid the problems in maintenance in the future.

3 CONCLUSIONS

The important conclusions drawn from the present study are summarized as follows:

- The initial Quality of work is the most important factor, as if it is there, the least road maintenance problems will arise.
- Data of inventory is also important because from this data, the road maintenance can be evaluated effectively to make sure the maintenances are in order and the strategy for the future can be worked out.
- The flow of funds should be properly scheduled such that the funds be available at the right time and the Road maintenance work be taken up at the right time in the initial stages itself.

- Training to be provided to the concerned maintenance staff, from time to time, so as to acquaint them with the latest developments in the road maintenance and management system.
- Work Departments can improve the ways of monitoring or supervision.

Activity :- Interview & Questionnaires for JPAR4

Activity :- Interview & Questionnaires for JSR4

4 REFERENCES

• Agarwal, P.K., "*Road Condition Evaluation, Prioritization and Optimal Resource Allocation for Rural road Maintenance at Network Level*," Ph.D. thesis, Department of Civil Engineering, IIT Kanpur, Kanpur, 2006

• Haas, R., Hudson, W. R. And Zaniewski, J, "*Modern Pavement Management*,'' Krieger Publishing company, Malabar, Florida USA 1994.

• Lee, H.N., Jitprasithsiri, S., Lee, H., and Sorcic, R.G., "*Development of Geographic Information System –Based Pavement Management System for Salt Lake City*", Transportation research record 1524, TRB, National Research Council, Washington, D.C.,1996, pp. 16-24.

•NHAI, http://www.nhai.org/road netwok.htm, website of National Highway Authority of India, 2010.

• Qiu, Y., Dennis, N.D. and Elliott, R.P., (2000) "*Design Criteria for Pavement Deformation of Sub grade Soils in Flexible Pavements for Low Volume Roads*," Journal of the Japanese Geotechnical Society of Soils and Foundations, Vol.40, No.1, pp.1-10

• Sood, V.K. "*Rural Road Maintenance Strategy- An Overview*," proceeding ICORT 1995, Department of Civil Engineering, University of Roorkee, 1995

• Sahoo, U.C., Reddy, M.A. and Reddy, K.S.,(2010), "*Rational Design Criteria for Sustainable Rural Roads*," Grameen Sampark, News Letter, National Rural Road Development Agency (NRRDA),Ministry of Rural Development, GOI, New Delhi, 2010. pp 34-39.

• www.gisdevelopment.net, site accessed in March, 2010
