Pavement Evaluation Study of Road Stretches Constructed using Nanotechnology Adopted by Zydex Industries

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Abstract— The main objective of the present evaluation work is to conduct pavement performance evaluation of nanotechnology using Terraprime, Nanotac and Zycosoil constructed under the technology demonstration stretches of NAMMA GRAMA NAMMA RASTE YOJANE (NGNRY) under KRRDA, Govt of Karnataka. The study area is selected are Bennenhalli To T-12 (1.95km) Road of GubbiTaluk, Hosur To L-066(1.765km) Road of TipturTaluk, and Banjarahatti to L-116(0.3km) Road C.N.Halli Taluk, Tumkur District. The study includes Structural Evaluation (Deflection study using BBD and Axle load studies), Functional Evaluation (Roughness measurement using MELIN and Pavement Condition Survey by Visual Rating method) and Geotechnical Investigation (Grain Size Analysis, Atterberg Limits and CBR) of the mentioned road stretches.

Key words: Zydex, Pavement Evaluation

I. INTRODUCTION

The importance of having a proper road network for the development of any country is very essential. The India was realized this quite early, the first road development plan started in 1941-1961(Nagpur road plan).Highlighted the long term road infrastructure requirements of the country and classified road network as National highway(NH), State highway(SH), Major district road(MDR), Other district road(ODR), Village road(VR). Out of these ODR and VR are classified as rural roads. The rural roads are considered as low volume roads. In India the rural roads play a vital role for the development of country. There are more than six lakhs villages. The climatic condition also vary from place to place to a great extent Rural roads are feeder roads serving the rural areas, where agriculture is the primary occupation providing outlets to the market is essential. A large number of villages in India still not connected to the all-weather roads. A good road network is also necessity for the employment opportunities basic necessity like health, education etc. Different rural road development plans in India as fallows.

- Minimum Needs Plan (MNP)
- Rural Landless Employment Guarantee Programme(RLEGP),
- National Rural Employment Programme(NREP),
- JawaharRozgarYojana(JRY),
- Community Development Programmes For Rural Roads,
- Food For Work Programme,

The above six programmes were launched to achieve the goal for rural connectivity. The ministry of rural road Government of India is recently has launched a massive programme called PRADHAN MANTRI GRAM SADAK YOJANA (PMGSY), in 25th December 2000 for the first time focussing directly on the rural roads connecting the unconnected roads.

Accordingly for the year 2000-2001, the Programme will cover Habitations having a population of more than 1000 persons. Where a State has no uncovered Habitations of this population size, smaller habitations may also be covered, subject to the minimum population size being 500. In case of hilly/desert it may not be less than 250.

As per IRC all-weather road is defined as a road, which is negotiable during all weathers, except at major river crossings. This implies that the road bed is drained effectively by adequate cross drainage structures like minor bridges, causeways. Rural roads under PMGSY scheme are required to be constructed proper engineering standards. The stress is laid on durability, planning standards, specifications, detailed project reports, quality assurance (QA), maintenance, monitoring system operations manual and programming of assets being created. In the initial years of the programmed annual investments were about 2,500 Crores to 3,000 Crores Rupees. Currently the investments are in the order of 20,000Crore Rupees per year.

II. LITERATURE SURVEY

A. "ZycoSoil Nanotechnology Multilayer Waterproofing Treatment of Soil and Asphalt Concrete in Road Construction" (1)

The study was conducted for the long term evaluation of 3 post man soon years for effectiveness of Zycosoil nanotechnology multilayer water proofing treatment of soil and asphalt concrete in road construction. Zycosoil applied on the compacted soil layer for making it water proof and permeable layer in a water logged areas and problematic soil like black cotton (BC) soil. Prime/tack coat using Zycosoil solution sprayed on WBM/Carpet layer for improved penetration, wetting and quick set. Zycosoil added in hot mix asphalt layer at 0.1% by weight of binder and mixed thoroughly with circulating pump. It is mixed with heated aggregates in drum mix plant at site. The following conclusion was drawn.

- Long term evaluation by GERI, Vadodara for 3 post monsoon years for conclusive effectiveness of the technology
- Initial visual inspections in June 2011 show no deterioration.

B. "Zycosoil nanotechnology application in Leh road,BRO" (2)

Zycosoil mixed with hot mix asphalt layer (HMA), binder stirred it thoroughly with circulating pump .It was heated with aggregates in drum mix plant at site. It was found that

laying and compacting of asphalt concrete was better and non-sticking of aggregates on compacted rollers it takes 4 no of passes. Whereas conventional method takes rolling of 8 passes for the same amount of compaction. The aggregate coated with asphalt mixture was found shiny.
Stripping value at 0.1 percent to 0.15 percent dose was found 90 to 100 percent.

- Better bonding and improved stability laboratory test samples of Zycosoil mixed Asphalt – concrete mixture.
- Zycosoil mixed easily in hot melted asphalt
- Zycosoil is easily mixed in melted asphalt tank. The bounding strength and stability improved.
- The international practice of highway found that 0.5mpa has to give bond strength. The average strength of this sample was 0.6mpa.

C. "Zycosoil as an additive for bituminous road works" (3)

The objective of the report was to know the effects of Zycosoil on the properties of the bitumen and to know the stripping properties on good basalt and bad weathered stones in bitumen after addition of Zycosoil as an additive. The bitumen used in this case is 60/70 penetration grade. Zycosoil is a water soluble compound nanotechnology offers the water repellent Nano layers on all types of soil and aggregate. It converts the water loving silano to water repellent siloxane bonds. The additive is directly added to hot asphalt binder mixed it thoroughly and then used. The polar surface of the aggregate converted to non-polar surface. The percentage of air voids in mix decreases from 4.4 in case of bitumen to 4.3 in case of binder coating 0.1persentage additive. The addition of additive requires continuous stirring to have homogeneous mixture. By adding an additive stripping property of the aggregate is improved. Based on the laboratory investigations the following conclusions can be drawn.

- Marshall Stability, Marshall Flow, Compacted density, of mix and Softening point values increases.
- Temperature susceptibility of the binder is improved as softening point value is increases which will result in to the high strength mixes.
- Penetration value and ductility value decreases.
- Looking to the above conclusions it seems that with addition of Zycosoil as an additive, bitumen becomes harder and with which high strength mixes are possible.
- Stripping value of aggregates is improved by using Zycosoil as an additive.
- An experimental stretch construction using Zycosoil as additive material in bituminous wearing course and field performance study till failure is suggested for further proposed work.

D. "Nanotechnology in flexible pavements" (4)

The study was conducted on nanotechnology in flexible pavement benefits of using nanotechnology to make soil water proof like increment in California bearing ratio (CBR) value in wet conditions or negligible maintenance, less materials required in construction of road because of reduction in thickness required of pavement. Nanotechnology based improvement to pavement performance will result in significant cost savings to pavement agencies around the world. Nanotechnology chemicals have been developed to prepare in- situ water proofed soil layer during pavement construction. The technology addresses the sub surface drainage problems in road construction. It also has solutions for the following issues like loss in strength and expansion in wet conditions for soil sub-grade reduced water absorption through road shoulders and sides, utilization of in situ soil. Nanotech converts water loving dust /dirt to asphalt loving surfaces. Cationic bitumen emulsion has poor wetting properties results in to poor coverage of tack coat. Nanotech lowers the surface tension of the cationic bitumen emulsion leads to excellent wetting and complete coverage cationic bitumen emulsion has poor mechanical stability results in to clogging of nozzles and uniform application nanotech keeps the nozzle clean by improving the stability of cationic bitumen emulsion. From the study the following conclusion was drawn.

1) Reduction of Materials Used

As we know pavement based design and thickness of sub-base depends upon CBR value results in reduction of thickness of sub- base which means materials required for sub- base is less quantity.

2) Cost comparison

Conventional method of pavement is having less initial cost and high maintenance cost. Pavement making using nanotechnology may have high initial cost but it has nearly no maintenance costs which will affect the economy of road long time.

3) Durability

As we know the conventionally made roads are not very long lasting, they hardly remain in good condition for 10 years. But having Nanotechnology all due to water are eliminated the roads life for good conditions up to 20-25 years.

III. Objectives of the Present Study

- Functional evaluation of the selected road stretches by conducting pavement condition survey and by MERLIN.
- Structural evaluation of the selected road stretches by conducting Axle load Survey, Benkelman Beam Deflection Studies.
- To know the Properties of soil in these road stretches by conducting Geotechnical investigation on the collected soil sample.

IV. Methodology Adopted

Field investigations were carried out to know the functional and structural behaviour of the existing pavement structures.

1) Functional Evaluation

- Pavement roughness/unevenness survey by MERLIN
- Pavement condition survey by manual method.

2) Structural Evaluation

- Structural adequacy of pavement using Benkelman beam deflection method (BBD).
- Classified volume count of vehicles.
- Axle load survey for commercial vehicles using portable weighing pads.

V. PAVEMENT PERFORMANCE EVALUATION

The Present Investigation aimed at studying the Structural and Functional behavior of the existing three rural roads mentioned below which are located in different parts of Tumkur District of Karnataka state.

Distict	Taluk	Package No.	Road Name	Chainage
Tumkur	Gubbi	KS-25-04	Bennehalli To T-12	0.0-1.95 KM
Tumkur	Tiptur	KS-25-05	Hosu To L-066	0.0-1.76 KM
Tumkur	C.N.Halli	KS-25-14	Banjarahatti To L-116	0.0-0.3 KM

Table: 5.1 Abstract of Three Village Roads

VI. RESULTS AND DISCUSSIONS

A. *For Gubbi Road*

1) Benkelman Beam Studies

SI. NO.	Chainage (km)	Charecteristic Deflection value (Dc mm)	Aveage Characteristic Deflection Value
1	0.0-0.5	0.510	**0.607**
2	0.5-1.0	0.949	
3	1.0-1.5	0.640	
4	1.5-1.95	0.331	

Table 6.1: Average Characteristic Deflection Value

2) Classified Volume Counts

SI. NO.	PCU	CVPD	ESAL	Category of Traffic
1	171	55	121,3332	T4

Table 6.2 Average PCU, CVPD, ESAL and Category of Traffic

3) Axle Load Survey

SI.NO.	Average Equivalent Factor (E.F) of all Vehicles
1	0.0793

Table 6.3 Average Equivalent Factors

4) Merlin Results

SI. NO.	Chainage (km)		IRI Value (m/km)	Average IRI Value (m/km)
	From	To		
1	0	1	3.183	**3.242**
2	1	1.95	3.301	

Table 6.4 Average Roughness (IRI) Values

5) Pavement Condition Survey

SI. NO.	Chainage (km)		Ratings	Pavement Condition Index (PCI)
	From	To		
1	0	1	5	**Very Good**
2	1	1.95	5	**Very Good**

Table 6.5: PCI VALUE and RATING

6) Geotechnical Investigations of Soil- Laboratory Test Results

Chainage (km)	IS Soil Classification	Atterberg Limits (IS-2720 Part-5,1985)			Compaction Parameters (IS-2720 Part-8,1983)		CBR (IS-2720 Part- 5,1983)
		LL(%)	PL(%)	PI(%)	MDD (g/cc)	OMC (%)	56 Blows (%)
0.0	SP	29.8	19.3	10.4	1.81	10.0	5.34
0.5	SW	25	16.1	8.88	1.84	9.44	4.16
1.0	SP	31.6	19.0	12.5	1.89	9.04	4.44
1.5	SP	28	15.0	13.0	1.88	10.0	5.13
1.95	SW	24.8	11.8	13.0	1.87	8.95	4.81

Table 6.6: Soil Results

Note: SP-Poorly graded sand and gravelly sand, SW- Well graded sand and gravelly sand

7) Designed Crust Thickness Results

Chainage (km)	DPR Results		Obtained Results		Remarks
	CBR Values(mm)	Pavement Thickness(mm)	CBR Values(mm)	Pavement Thickness(mm)	
0 to 1	5	300	4.6	375	The thickness as per DPR is 300mm is Retained and the Comparison is only for Academic purpose
1 to 1.95	5	300	4.9	375	

Table 6.7: Design Crust Thickness

B. *For Tiptur Road*

1) Benkelman Beam Studies

SI. NO	Chainage (km)	Characteristic Deflection value (Dc mm)	Aveage Characteristic Deflection Value
1	0.0-0.5	0.329	**0.379**
2	0.5-1.0	0.340	
3	1.0-1.5	0.222	
4	1.5-1.75	0.628	

Table 6.8: Average Characteristic Deflection Value

2) Classified Volume Counts

SI.NO.	PCU	CVPD	ESAL	Category of Traffic
1	179	56	87,560.2	T3

Table 6.9 Average PCU, CVPD, ESAL and Category of Traffic

3) Axle Load Survey

SI.NO.	Average Equivalent Factor (E.F) of all Vehicles
1	0.1897

Table 6.10 Average Equivalent Factors

4) Merlin Results

SI.NO.	Chainage (km)		IRI Value (m/km)	Average IRI Value (m/km)
	From	To		
1	0	1	3.295	

2	1	1.75	2.940	**3.117**

Table 6.11 Average Roughness (IRI) Values

5) Pavement Condition Survey

SI.NO.	Chainage (km)		Ratings	Pavement Condition Index (PCI)
	From	To		
1	0	1	5	**Very Good**
2	1	1.75	5	**Very Good**

Table 6.12: PCI VALUE and RATING

6) Geotechnical Investigations of Soil- Laboratory Test Results

Chainage (km)	IS Soil Classification	Atterberg Limits (IS-2720 Part-5,1985)			Compaction Parameters (IS-2720 Part-8,1983)		CBR (IS-2720 Part- 5,1983)
		LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)	56 Blows (%)
0.0	SP	31.6	21.1	10.5	1.67	13.86	5.81
0.5	SP	31.2	22.2	9.0	1.76	14.34	5.42
1.0	SP	34.5	26.0	8.5	1.72	14.61	6.65
1.5	SP	32.3	23.3	9.0	1.78	14.28	6.34
1.75	SP	30.4	20.2	10.2	1.84	13.76	6.0

Table 6.13: Soil Results

Note: SP-Poorly graded sand and gravelly sand,

7) Designed Crust Thickness Results

Chainage (km)	DPR Results		Obtained Results		Remarks
	CBR Values (mm)	Pavement Thickness (mm)	CBR Values (mm)	Pavement Thickness (mm)	
0 to 1	7	225	5.9	275	The thickness as per DPR is 225mm is Retained and the Comparison is only for Academic purpose
1 to 1.75	7	225	6.1	275	

Table 6.14: Design Crust Thickness

C. For C.N.Halli Road

1) Benkelman Beam Studies

Si. No.	Chainage (km)	Charecteristic Deflection value(Dc mm)	AveageCharacteristic Deflection Value (mm)
1	0.0-0.3	0.519	**0.519**

Table 6.15 Average Characteristic Deflection Value

2) Classified Volume Counts

SI.NO.	PCU	CVPD	ESAL	Category of Traffic
1	161	49	144,859.21	T4

Table 6.16 Average PCU, CVPD, ESAL and Category of Traffic

3) Axle Load Survey

SI.NO.	Average Equivalent Factor (E.F) of all Vehicles
1	**0.0475**

Table 6.17 Average Equivalent Factors

4) Merlin Results

SI. NO.	Chainage (km)		IRI Value (m/km)	Average IRI Value(m/km)
	From	To		
1	0	0.3	3.533	**3.533**

Table 6.18 Average Roughness (IRI) Values

5) Pavement Condition Survey

SI.NO.	Chainage (km)		Ratings	Pavement Condition Index (PCI)
	From	To		
1	0	0.3	5	**Very Good**

Table 6.19: PCI VALUE and RATING

6) Geotechnical Investigations of Soil- Laboratory Test Results

Chainage (km)	IS Soil Classification	Atterberg Limits (IS-2720 Part-5,1985)			Compaction Parameters (IS-2720 Part-8,1983)		CBR (IS-2720 Part-5,1983)
		LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)	56 Blows (%)
0.0	SP	35.6	19.3	16.2	1.78	14.8	4.5
0.3	SP	35.2	18.4	16.7	1.80	14.6	4.5

Table 6.20: Soil Results

Note: SP-Poorly graded sand and gravelly sand, SW- Well graded sand and gravelly sand

7) Designed Crust Thickness Results

Chainage (km)	DPR Results		Obtained Results		Remarks
	CBR Values (mm)	Pavement Thickness (mm)	CBR Values (mm)	Pavement Thickness (mm)	
0 to 0.3	6	300	4.5	375	The thickness as per

					DPR is 300mm is Retained and the Comparison is only for Academic purpose

Table 6.21: Design Crust Thickness

VII. CONCLUSIONS

A. Name of the Road: Bennehalli to T-12

The pavement Condition Survey, Axle Load survey, MERLIN and Benkelman Beam Deflection studies were conducted on the Bennanhalli to T-12 Road stretch and the Following observations are made:

1) The traffic Survey was done for a period of 24 hours only. The total Traffic Count and Category of Traffic are Tabulated in Table 6.2.
2) The Road stretch is in Good Condition. The stretch has few minor patchworks, raveling, cracking and longitudinal depression at various chainages .The surface is free from the distress such as Pot Holes, Edge Drop, rutting during the time of survey.
3) The Benkelman Beam Deflection Studies were carried out on the above mentioned road stretch and test was conducted as Per IRC-81 1997. The observed average characteristic deflection value (Dc) for the stretch is 0.607 mm*. So, from the observed values it can be concluded that the Relaying of the pavement is not warranted.

The BBD values should not be taken as reference for the design of overlay. The characteristic deflection values are considered to understand the overall deflection characteristics of the pavement under a standard load. Since the surface course is not a structural layer, it is only a functional layer.

4) The Axle load survey was carried out on the above stretch for a period of 24 Hours. The test was conducted as per IRC SP-19 2001 and the Results are shown in Table No 6.3. The observed equivalent factor is 0.0773.From the observed results it can be concluded that the vehicles are not over loaded.
5) The MERLIN survey was conducted on the above stretch and the observed average International Roughness Index (IRI) value was found to be 3.242 m/km. Since, the observed value is just above 3.0m/km, the Roughness Value has a less significance on the vehicle operation cost.

B. Name of the Road: Hosur village to L-066

The pavement Condition Survey, Axle Load survey, MERLIN and Benkelman Beam Deflection studies were conducted on the Hosur to L-066 Road stretch and the Following observations are made;

1) The traffic Survey was done for a period of 24 hours only. The total Traffic Count and Category of Traffic are Tabulated in Table 6.9.
2) The Road stretch is in Good Condition. The surface is free from the distress such as Pot Holes, Raveling, Edge Drop, Cracking, rutting, and Longitudinal Depression during the time of survey.
3) The Benkelman Beam Deflection Studies were carried out on the above mentioned road stretch and test was conducted as Per IRC-81 1997. The observed average characteristic deflection value (Dc) for the stretch is 0.38 mm*. So, from the observed values it can be concluded that the Relaying of the pavement is not warranted.

The BBD values should not be taken as reference for the design of overlay. The characteristic deflection values are considered to understand the overall deflection characteristics of the pavement under a standard load. Since the surface course is not a structural layer, It is only a functional layer.

4) The Axle load survey was carried out on the above stretch for a period of 24 Hours. The test was conducted as per IRC SP-19 2001 and the Results are shown in Table 6.10. The observed equivalent factor is 0.1897.From the observed results it can be concluded that the vehicles are not over loaded.
5) The MERLIN survey was conducted on the above stretch and the observed average International Roughness Index (IRI) value was found to be 3.12 m/km. Since, the observed value is just above 3.0m/km, the Roughness value has a less significance on vehicle operation cost.

C. Name of the Road: Banjarahatti to L-116

The pavement Condition Survey, Axle Load survey, MERLIN and Benkelman Beam Deflection studies were conducted on the BanjaraHatti to L-116 Road stretch and the Following observations are made;

1) The traffic Survey was done for a period of 24 hours only. The total Traffic Count and Category of Vehicles are Tabulated in Table 6.16.
2) The Road stretch is in Good Condition. The surface is free from the distress such as Pot Holes, Ravelling, Edge Drop, Cracking, rutting, and Longitudinal Depression during the time of survey.
3) The Benkelman Beam Deflection Studies were carried out on the above mentioned road stretch and test was conducted as Per IRC-81 1997. The average observed characteristic deflection value (Dc) for the stretch is 0.519 mm*. So, from the observed values it can be concluded that the Relaying of the pavement is not warranted.

The BBD values should not be taken as reference for the design of overlay. The characteristic deflection values are considered to understand the overall deflection characteristics of the pavement under a standard load, since the surface course is not a structural layer, It is only a functional layer.

4) The Axle load survey was carried out on the above stretch for a period of 24 Hours. The test was conducted as per IRC SP-19 2001 and the Results are shown in Table 6.17. The observed equivalent factor is 0.0475. From the observed results it can be concluded that the vehicles are not over loaded.
5) The MERLIN survey was conducted on the above stretch and the observed average International

Roughness Index (IRI) value was found to be 3.533 m/km. Since, observed value is just above 3.0m/km, it has less importance on the, vehicle, operation.

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