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Widening and Renovation of Hill Road Pavement from Doddabetta to Kattabettu in the Nilgiri district

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ABSTRACT: A Hill road is one which passes through a terrain with a cross slope of twenty five percent or more. A hilly or Mountainous area is characterized by a highly broken relief with widely differing elevations, steep slopes, deep gorges and a great number of water courses. Owing to complex topography, the route has to be ineffectively increased. Flexible pavements are especially affected by moving vehicles, as a result of moving vehicles the pavement starts deteriorate. The existing road has been badly damaged due to heavy intensity of rain and by the due course of time. The main objectives of this project involve widening of the existing road up to the desirable limit and to renovate the pavement where the roads have been heavily damaged. The results indicate that the Benkelman beam method was used for the calculation of the deflection behavior against dynamic vehicle loading for flexible pavements.

KEYWORDS: Elevation, Intensity, Modeling, Pavement, Benkelman beam method, Deteriorate, Flexible.

1 INTRODUCTION

The Nilgiri hills are divided from the Karnataka plateau to the north by the Moyar River and from the Anaimalai Hills and Palni Hills to the south by the Palghat Gap. The Nilgiri District of Tamil Nadu lies within these mountains. Its latitudinal and longitudinal dimensions are 130 km (Latitude: 11° 08' to 11° 37' N) by 185 km (Longitude: 76° 27' E to 77° 4' E). Central location is: 11°22’30”N 76°45’30”E. It has an area of 2,479 square kilometers (957 sq mi).[1]

It is situated between 8°5 North and 13° 35’ North and between 76° 15’ East and 80° 20’ East, the Nilgiri road network is a 29 kms stretch from Dodabetta to Kattabettu. Doddabetta is at an elevation of 2200 meters above mean sea level. Agalar which is between Doddabetta and Kattabettu is 6000 feet above the sea at the South East Corner of the Nilgiri Plateau, and at the head of the principal pass from the plains. The 29 kms long road network from Doddabetta to Kattabettu lies partly Nilgiri District of Tamil Nadu, on the eastern slopes of the Western Ghats. The road network passes through fourteen stations namely Doddabetta, Attabettu, Nehruji nagar, Moradacombai, Thuneri, Agalar, Kothumudi, Periyarnagar, Thirukadi, Ajjoor, Pillicombai, Kovilmedu, Kudumunai, and Kattabettu. The road network comes under the classification of Major District Road (MDR). The road is an important road within a district serving areas of production and markets and connecting those with each other. The road is a One-way road and has lower speed and also geometric design specifications than National Highways and State Highways. [2]

Rainfall in this region averages 3,000–4,000 mm (120–160 in) with localized extremes touching 9,000 mm (350 in). The eastern region of the Western Ghats which lie in the rain shadow, receive far less rainfall averaging about 1,000 mm (40 in) bringing the average rainfall figure to 2,500 mm (150 in).[3]

2 OBJECTIVES

The study has been carried out with the following objectives,

- Widening of the existing road up to the desirable limit.
- To renovate the pavement where the roads have been heavily damaged.
- The project also proposed the need of porous pavements where it was highly affected due to the intensity of rain.

3 METHODOLOGY

3.1 BENKELMAN BEAM METHOD

Flexible pavements are especially affected by moving vehicles. As a result of the moving vehicles, the pavement starts to deteriorate. For the determination of the structural capacity of the pavement, non-destructive testing equipments are used. These are mainly Benkelman beam, Dynaflect and falling weight deflectometer (FWD). The Benkelman Beam measures the static deflections and it is operated on the basis of lever arm principle. Measurement is made by placing the tip of the beam between the dual tires and measuring the pavement surface rebound as the truck is moved away. The test is of low cost but it is time consuming and labour intensive in carrying out the test. In Falling Weight Deflectometer Test, the falling weight deflectometer is mounted in a vehicle. The sensors are lowered to the pavement surface and the weight is dropped. The test measures the impact load response of flexible pavement. It has the potential advantages that it is quick to perform and the impact load can be readily changed. Moreover, the impact action of falling weight appears to be more accurately representing the transient loading of traffic.

3.2 TRAFFIC CENSUS

Table 1. Traffic Census for a Period of One week

From	To	Vans, Jeep, etc.,	Light Commercial Vehicles	Buses	Two and three axle vehicles
27/5/14	28/5/14	1172	1008	534	155
28/5/14	29/5/14	1142	977	536	167
29/5/14	30/5/14	1159	968	523	198
30/5/14	31/5/14	1146	984	515	124
31/5/14	01/6/14	1189	972	508	149
01/6/14	02/6/14	1173	983	552	176
02/6/14	03/6/14	1192	956	509	192
Total for the week		8173	6819	3676	1140
Average daily traffic		1168	975	525	166
CVPD		2834			

3.3 GROUP INDEX METHOD

In order to classify the fine grained soils within one group and for judging their suitability as sub grade material, an indexing system has been introduced in HRB classification which is termed as Group Index. Group Index is function of percentage material passing 200 mesh sieve (0.074mm), liquid limit and plasticity index of soil and is given by equation (0.074mm). [10]Liquid limit and plasticity index of soil and is given by equation:

$GI=0.2a+0.005ac+0.01bd$

Here,

a=that portion of material passing 0.074mm sieve, greater than 35 And not exceeding 75 %
b=that portion of material passing 0.074mm sieve, greater than 15 And not exceeding 35%
c = that value of liquid limit in excess of 40 and less than 60
d = that value of plasticity index exceeding 10 and not more than 30

3.4 CBR METHOD

The CBR method of pavement design was first used by the California Division of Highways as a result of extensive investigations made on pavement failures during the years 1928 and 1929 (Corps of Engineers, 1958). To predict the behaviour of pavement materials, the CBR was developed in 1929. Tests were performed on typical crushed stone representative of base course materials and the average of these tests designated as a CBR of 100%. Samples of soil from different road conditions were tested and two design curves were produced corresponding to average and light traffic conditions. From these curves the required thickness of Sub-base, base and surfacing were determined. The investigation showed that soils or pavement material having the same CBR required the same thickness of overlying materials in order to prevent traffic deformation. So, once the CBR for the sub grade and those of other layers are known, the thickness of overlying materials to provide a satisfactory pavement can be determined.[9]

3.5 EXISTING PAVEMENT CONDITIONS

Fig. 1. Formation of Ruts at Pillicombai

Fig. 2. Damaged road surface in Periyarnagar

Fig. 3. Damaged road surface in Agalar

4 RESULTS AND DISCUSSIONS

In this study the soil samples from Doddabetta, Agalar, Kattabettu were collected and it is tested. The test results of plastic limit, liquid limit, plasticity index and optimum moisture content are given in table 2.Soaked CBR test were conducted for the soil samples and the test results are given in table 2. The details of the existing pavement thickness are represented in table 3.

Since the GWT is too long to influence the sub grade moisture, the design moisture may be close to the optimum moisture content. For in-situ dry density of 1.68 gm/c, GWT depth of 10 m, PI of 13 and average annual rainfall of 75 cm, the Equilbrium Moisture Content works out to about 1 %. The optimum moisture content of 12% being higher, the CBR value of 5 may be taken for sub grade strength. The pavement portion that has to be renovated is designed and it is given in table 4. The pavement is designed by using group index method and CBR method. The proposed pavement thickness is shown in table 5, 6, 7 and 8.

In Nilgiri district the amount of rainfall is very high. In order to avoid the water stagnation paver blocks can also be preferred. The main benefit over other materials to create a hard surface are that the individual bricks that go together to make up the block paved surface are able to be lifted up and then replaced. This allows for remedial work to be carried out under the surface of the paving without any visible notice to the surface once the paving bricks have been replaced. This is kind of brick paving is said to be flexible paving. Paver block is shown in figure 4.

Table 2. Soil Testing Details

Station	Soil sample	PRA Classification	LL	PL	PI	MDD	OMC %	CBR at 97% after 4 days soaking
Doddabetta	Silty soil	A.4	26	8	8	1.908	10.4	5
Agalar	Silty soil	A.4	28	12	6	1.992	10.3	5
Kattabettu	Silty gravel	A.2.4	31	17	4	2.011	9.8	6

Table 3. Existing Pavement Thickness

Chainage	Carriageway width (m)	Gravel (mm)	Water Bound Macadam (mm)	Bitumen Surface (mm)
Doddabetta	3.75	155	150	42
Agalar	3.75	155	150	40
Kattabettu	3.75	155	150	38

Table 4. Improvement Portion Design

Chainage	MSA	BBM Deflection	Thickness required as per IRC 18 (mm)	Proposed Thickness (mm)
Doddabetta	8.74	1.547	110	114
Agalar	8.74	1.523	108	114
Kattabettu	8.74	1.506	106	114

Table 5. Pavement Thickness by Group Index Method

Station	Sub – base (mm)	Base (mm)	Surface course (mm)	Proposed thickness (mm)
Doddabetta	70	300	40	410
Agalar	70	300	40	410
Kattabettu	70	300	40	410

Table 6. Pavement Thickness by California Bearing Ratio Method for 5 Years

Station	Bitumen course (mm)	DBM (mm)	Base course (mm)	Sub base (mm)	Proposed thickness (mm)
Doddabetta	40	70	250	300	660
Agalar	40	70	250	300	660
Kattabettu	40	70	250	300	660

Table 7. Pavement Thickness by California Bearing Ratio Method for 10 Years

Station	Bitumen course (mm)	DBM (mm)	Base course (mm)	Sub base (mm)	Proposed thickness (mm)
Doddabetta	40	100	250	300	690
Agalar	40	100	250	300	690
Kattabettu	40	100	250	300	690

Table 8. Pavement Thickness by California Bearing Ratio Method for 15 Years

Station	Bitumen course (mm)	DBM (mm)	Base course (mm)	Sub base (mm)	Proposed thickness (mm)
Doddabetta	40	124	250	300	714
Agalar	40	124	250	300	714
Kattabettu	40	124	250	300	714

Fig. 4. Paver Blocks for the Drainage of Water

5 Conclusion

The pavement is designed as a flexible pavement. The CBR method as per IRC 37-2012 is most appropriate method than available methods. The pavement is designed as a flexible method from which each method is designed on the basis of their design thickness from which each method has different cost analysis of a section, from which CBR as per IRC is most appropriate in terms of cost analysis. It is observed that flexible pavements are more economical for lesser volume of traffic. The life of flexible pavement is near about 15 years whose initial cost is low needs a periodic maintenance after a certain period and maintenance costs very high. The life of rigid pavement is much more than the flexible pavement of about 40 years approximately 2.5 times life of flexible pavement whose initial cost is much more then the flexible pavement but maintenance cost is very less.

The pavement thickness designed is found to be optimum for the present conditions of the hill road. As a result, the present road was widened and implemented the concept of Paver Blocks as a remedy for the water stagnation in the road due to Heavy rainfall conditions.

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