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Design of Flexible Pavement at Mangalam to Settipalli Road

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A B S T R A C T

Pavements are used for smooth, safety passing of traffic. We have generally two types of pavements flexible and rigid pavements. The development in automobile technology has resulted heavy moving loads on the previous highway for better transportation cost. In the project an attempt is made to design a road at mangalam to settipalli based on the method of pavement design. On the previous alignment of the road, soil samples are collected for the determination of soil characteristics like sieve analysis, consistency limits, California Bearing Ratio values and by adding stone dust the CBR value is increased and the thickness of road is reduced. Based on this the thickness of the flexible pavement is designed. The total road length is 2400 meters.

Keywords: Road design, Flexible pavement, Site investigation, Stone dust

1. Introduction

Transportation is an economic, industrial, social, and cultural development of any country. The transportation by road is only mode, which could give maximum service to one and all. India occupied 2 places in the context of of road network, as it is having a wide network of 33 lakh kms. The main purpose of this design is to provide a convenient route from Mangalam(RTO Office) to settipalli road. The road length is 2.40 km from mangalam to settipalli. In this project the road is categorized as other roads and it is designed as a flexible pavement according to IRC & IS specifications. The total road length of the road considered is 2.4 kms. The IRC procedure based on the california bearing ratio value is adopted to determine the thickness of the flexible pavement.

2. Literature Review

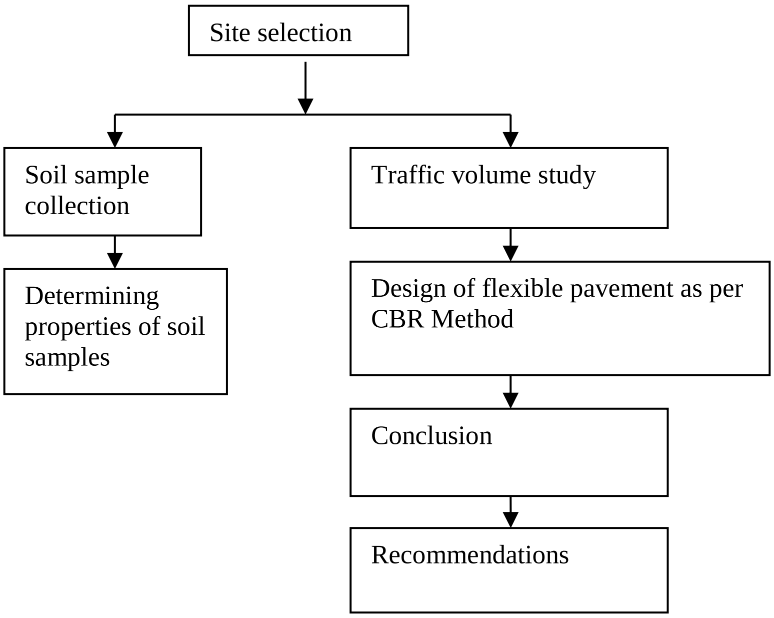
Chan (1998) describes the Group Index Method and California Bearing Ratio Method for design of flexible pavements. In Group Index Method the thickness is obtained by first determining the Group Index of the soil. The curves are plotted between Group Index of subgrade and thickness for various traffic conditions. In CBR method , the curves are plotted between California Bearing Ratio Percent and depth of construction.

Arora (2003) have reported various methods for design of flexible pavements. These various methods are Group Index Method method, CBR Method, California Resistance Value Method and McLeod Mehod. In the Group Index Method, the thickness of the base and surfacing is related to the volume of traffic. In CBR Method the curves are plotted between CBR and pavement thickness for light, medium, and heavy traffic. California Resistance value Method uses California Resistance value called R-value.

Punmia et. al (2005) have reported stresses in homogeneous mass; elastic deformation under circular road and burmister analysis for flexible pavement. Charts for vertical deflections have been developed. In Group Index Method, the curves are plotted between Group Index and thickness. In California Bearing Ratio Method curves are plotted between thickness of construction and California Bearing Ratio.

Das (2008) discusses the reliability issues in bituminous pavement design, based on mechanistic empirical – approach. Variabilities of pavement design input parameters are considered and realiability, for various proposed failure definitions of a given pavement is estimated by simulation as well as by analytical method. A methodology has been suggested for designing bituminous pavements for a given level of over all reliability by mechanistic empirical pavement design approach.

3. Methodology



4. Traffic Volume Study

It is defined as the procedure to determine mainly volume of traffic moving on the roads at a particular section during a particular time. These ae conducted to determine the number, movements, and classifications of roadway vehicles at given location.

S. No	Days	Session	Truck	Car	Auto rickshaw	Bikes	Cycles	Tractors	Total
1	Day 1	FN	6	4	15	18	2	9	54
		AN	4	7	12	20	1	12	56
2	Day 2	FN	5	5	14	22	1	7	54
		AN	3	7	16	18	3	4	51
3	Day 1	FN	6	7	18	22	3	10	66
		AN	5	9	15	16	1	8	54
4	Day 1	FN	4	8	14	21	1	12	60
		AN	6	6	18	17	1	10	58
5	Day1	FN	5	7	12	18	2	9	53
		AN	7	10	15	22	1	7	62
6	Day 1	FN	4	7	16	20	1	6	54
		AN	5	9	12	24	1	4	55
7	Day 1	FN	6	7	14	17	2	5	51
		AN	7	7	12	19	1	6	52

Table 1 Traffic volume study for different vehicles

Total vehicles = 782

Average number of vehicles = 782/7

= 111.71

= 112 vehicles / day

5. Experimental Investigation

1. Grain size analysis
2. Liquid limit
3. Compaction test

4. UCC test
5. CBR test

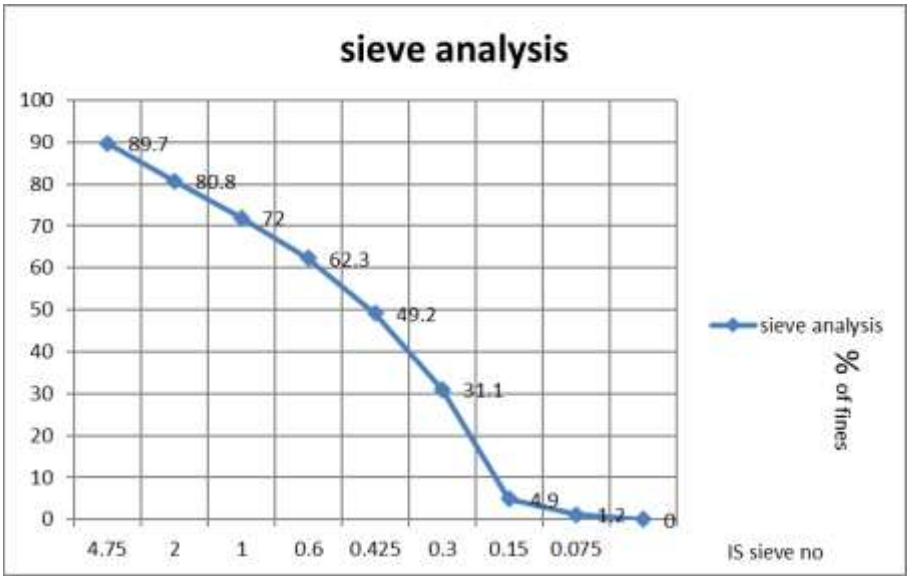
5.1 Grain size analysis

Grain size analysis is carried out to determine the relative percentages of different sizes of the particles in the sample. These sizes control the mechanical behaviour of coarse grained soil. Dry method of sievingis uesd for coarser fraction (retained on 4.75mm sieve) and wet method is used for finger fractions(retained on 75 microns sieve)

Figure 1 Grain size analysis

Table 2 Grain size analysis of dry sieve analysis

S.no	IS sieve Number	Weight of soil retained	Percentage of weight of soil retained	Cummulative precentage of weight of soil retained	Cummulative percentage of weight of soil passed
1	4.75 mm	103g	10.3	10.3	89.7
2	2 mm	89g	8.9	19.2	80.8
3	1 mm	88g	8.8	28	72
4	0.600mm	97g	9.7	37.7	62.3
5	0.425 mm	131g	13.1	50.8	49.2
6	0.300mm	181g	18.1	68.9	31.1
7	0.150 mm	262g	26.2	95.1	4.9
8	0.075 mm	37g	3.7	98.8	1.2
9	Pan	12g	1.2	100	0



Graph 1 Particle size distribution curve of dry sieve analysis

5.2 Liquid limit

Liquid limit is the water content which the soil changes from liquid state to plastic state.

Figure 2 Liquid limit

S.no	No of blows	Water content
1	6	25%
2	15	20%
3	24	18%
4	29	16%

Table 3 Liquid limit analysis

Liquid limit = 17%

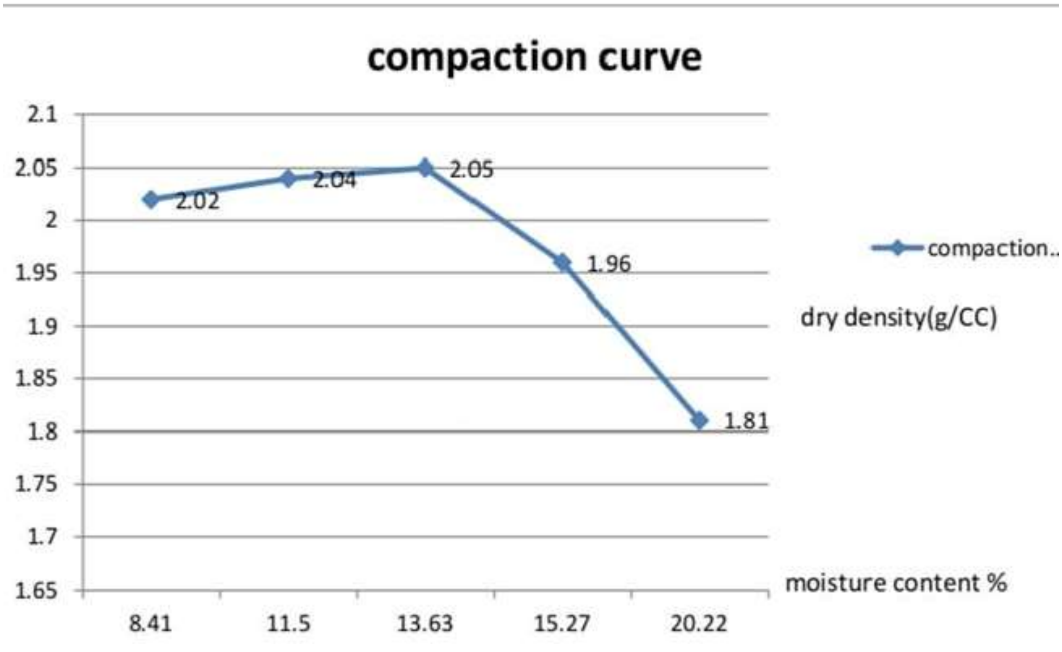
5.3 Compaction test

A laboratory procedure to determine the optimum water content at which a soil can be compacted so as to be yield the maximum dry density.

Figure 3 Compaction test

Optimum Moisture content = 13.%

Maximum dry density = 2.056 (g/cc)



Graph 2 Compaction curve of untreated soil

5.4 UCC TEST

Unconfined compression test is one of the fastest and cheapest methods of measuring shear strength of clayey soil. Unconfined Compressive Strength (UCS) is the load per unit area at which an unconfined cylindrical specimen of soil will fail in the axial compression test.

Figure 4 Ucc test analysis

Table 4 UCC test analysis

S. No	Dial reading (mm)	Deformation (mm) least count =0.01mm	Axial strain e = rL / L	Corrected area Ac =A /1-e (cm²)	Proving ring reading Axial force F (kg)	Compressive stress F / AC (Kg/cm²)
1	0	0	0	0	0	0
2	50	0.5	0.006410	11.41	3	0.262
3	100	1.0	0.012821	11.48	5.5	0.479
4	150	1.5	0.019231	11.56	6.5	0.562
5	200	2.0	0.025641	11.63	8	0.687

6	250	2.5	0.032051	11.71	9	0.768
7	300	3.0	0.038462	11.79	9	0.763
8	350	3.5	0.044872	11.87	9	0.758

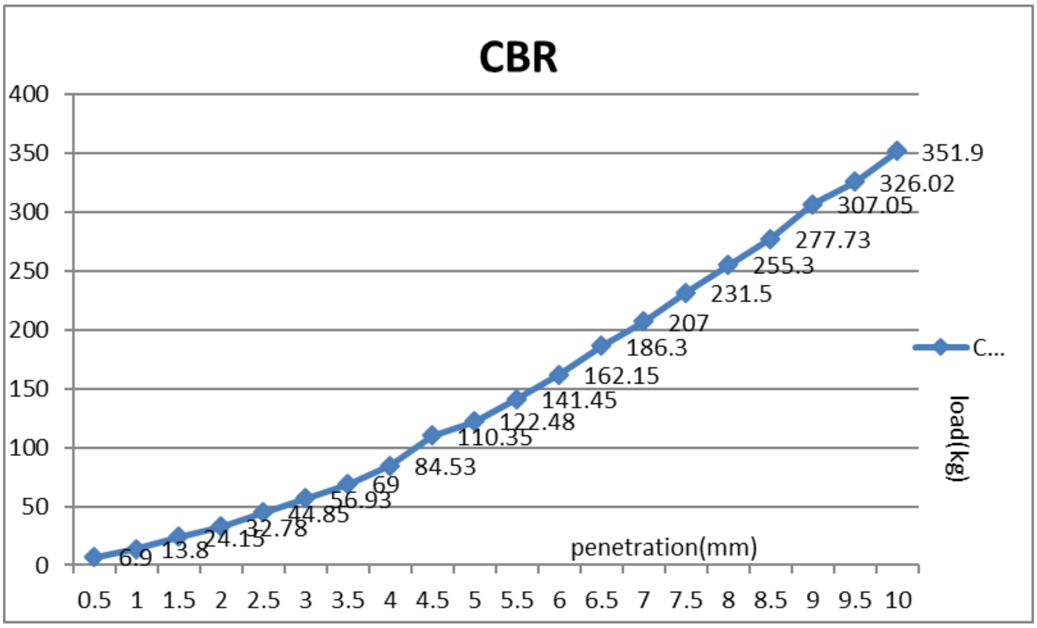
Unconfined compressive strength (qu) = 0.768 Kg/cm^2

Undrained shear strength (qu/2) = 0.384 Kg/cm^2

5.5 CALIFORNIA BEARING RATIO (CBR) OF A SOIL

The CBR test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achive an equal penetration on a standard crushed rock material. "The harder the surface, the higher the CBR value".

Figure 5 CBR test



Graph 3 CBR curve of untreated soil

CBR value at 2.5 mm penetration = 44.85/1370 *100

= 3.27 %

CBR value at 5 mm penetration = 122.48/2055 *100

= 5.96%

5.6 COMPACTION TEST & CBR TEST BY ADDING 10% OF STONE DUST.

Optimum Moisture Content = 12.37%

Maximum Dry Density = 2.11(g/cc)

California Bearing Ratio value = 5.93%

5.7 COMPACTION TEST & CBR TEST BY ADDING 15% OF STONE DUST.

Optimum Moisture Content = 8.65%

Maximum Dry Density = 2.16(g/cc)

California Bearing Ratio value = 8.48%

5.8 COMPACTION TEST & CBR TEST BY ADDING 20% OF STONE DUST.

Optimum Moisture Content = 12.37%

Maximum Dry Density = 2.11(g/cc)

California Bearing Ratio value = 5.93%

Design of Flexible Pavement using CBR method

1. Design to be carried out for single lane road
2. Number of commercial vehicles as per last count, P = 112 vehicles/day
3. Traffic growth rate per annum , r = 7.5% = 0.075
4. Design life of the pavement in years , n = 10 years
5. CBR value for untreated sub grade soil = 3%
6. CBR value for sub grade soil treated with stone dust = 8%

Design calculation

An estimated traffic to be carried

$N = P(1+r)^{x+10}$ vehicles/day

x = Number of years between last count and the year of completion of construction = 3 months = 0.3 years

$N = 112(1+0.075)^{0.3+10}$

= 235 vehicles / day

Computation of design traffic

$CSA = 365*N*F*D\ (1+r)^{n}-1/r$

$= 365*235*3.5*1\ (1+0.075)^{10}-1/0.075$

= 8.24 msa

Results and Dicussions

Untreated soil		Treated soil (stone dust)		
0%		10%	15%	20%
CBR	3.27%	5.93%	8.48%	7.29%

Table 5 Comparision of CBR values

According to recommended design for the traffic range

Total thickness of pavement for untreated soil for CBR of 3% and the traffic of 8.24 msa = **750 mm**

Total thickness of pavement for treated the soil with 15% stone dust for CBR of 8 % and the traffic of 8.24 **= 520 mm**

6. Conclusions

1. The thickness of the flexible pavement using IRC design charts were calculated.

2. We design the pavement according to the traffic volume condition.
3. For untreated soil without adding stone dust the total thickness of pavement will be 750 mm, hence it is more thickness of pavement.
4. By adding stone dust to the soil the CBR value has been increased.
5. By adding stone dust (15%) the total thickness of pavement will be reduced.
6. By adding stone dust (15%) the pavement will be economical.
7. So , it is suggestible to provide 520 mm thickness of pavement by using stone dust as a stabilizer.

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