VALUATION OF THE PERPETUAL PAVEMENTS COMPARED WITH THE CONVENTIONAL PAVEMENTS IN TROPICAL REGION OF INDIA

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ABSTRACT:

The design of the perpetual pavements are gaining acceptance in foreign countries as the traffic flow is increasing day by day, the economic and the environmental sustainability is also taking place. In this paper the perpetual pavements in the tropical region are compared with the normal conventional pavements, the economic feasibility is evaluated in this paper. The tropical climate has different effects on the pavements; the tests on the materials to be used in the pavements. The tests are performed such as marshal stability tests, bitumen tests, and the aggregate tests in which the tropical region has its availability. The binders like crumb rubber are also replaced with bitumen so that the cost will be reduced and it has the stability as that of the Bitumen and the tests are performed with crumb rubber as binding material. The design of the perpetual pavements are used of mechanistic empirical design (MED) philosophy where as normal conventional pavements has a proposed specific design. To perform the perpetual pavement design according to the traffic loads, the pavement design software MnPAVE design & the BCOA ME design. The two programmings are being analyzed and the thickness is being recommended by both the software's. The life cycle cost analysis is being evaluated from the perpetual pavements and compared with that of the normal conventional pavements.

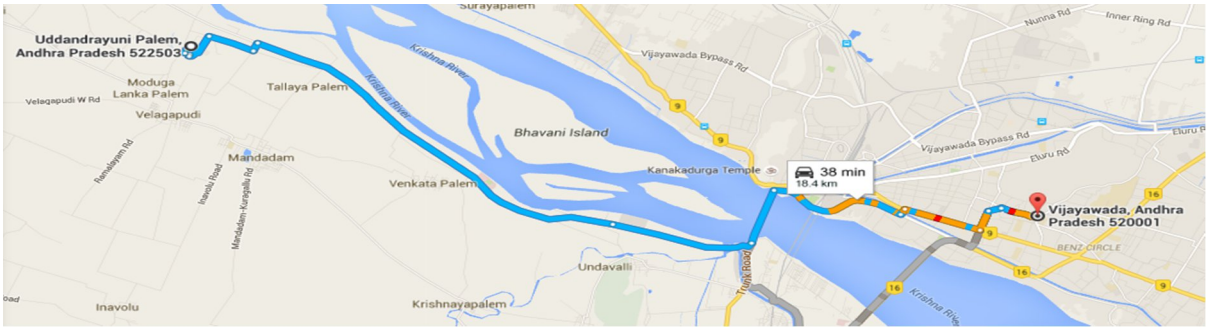
Keywords: Perpetual pavements, life cycle cost analysis, ME design, tropical climate, crumb rubber.

I. INTRODUCTION: Perpetual pavements have the structure which can last for more than 50 years. It has the bottom-up design and construction & Indefinite Fatigue Life. Many fibers can be used in these pavements as binders such as crumb rubber. Perpetual pavements are the Renewable Pavement Surface. Perpetual pavement has very High Rutting Resistance. These pavement can be Tailored for Specific Application. It has many advantages when compared with the conventional pavements. Perpetual pavement has very Consistent, Smooth and Safe Driving Surface. These asphalts are Environmentally Friendly. Researchers have used this idea and moreover black-top materials examination to develop a central relentless black-top essential thought. This idea utilizes a thick black-top over a solid establishment plan with three HMA layers, every one custom-made to oppose particular burdens. HMA base layer is the base layer composed particularly to oppose exhaustion breaking. Two methodologies can be utilized to oppose weariness splitting in the base layer. To start with, the aggregate

asphalt thickness can be made sufficiently awesome such that the pliable strain at the base of the base layer is unimportant. Then again, the HMA base layer could be made utilizing an additional adaptable HMA. This can be most effectively finished by expanding the black-top substance. Blends of the past two methodologies additionally work. Middle of the road layer is the center layer planned particularly to convey the greater part of the activity load. In this way it must be steady (ready to oppose rutting) and additionally solid. Dependability can best be given by utilizing stone-on-stone contact as a part of the coarse total and utilizing a fastener with the fitting high-temperature evaluating. Wearing surface is the top layer outlined particularly to oppose surface-started upsets, for example, top-down splitting and rutting. Other particular upsets of concern would rely on nearby experience. Perpetual pavements are mostly used in foreign countries for highways, but it is suggested that it can be used in all areas not only the highways. The municipal areas also generally go for normal conventional pavements and reconstruct after some years when there lifespan is completed. The perpetual pavements can be used in such areas so that the reconstruction cost will be reduced by increasing the thickness of the surface course and binder course layer. These types of pavements have the thickness of hot mix layer which is to be increased by 25 to 35 percent when compared to the normal conventional pavements.

II. LOCATION:

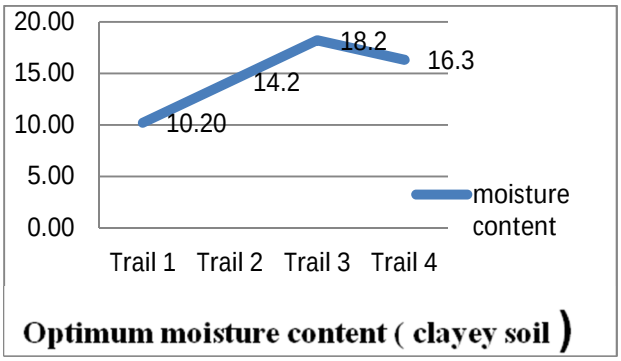
The perpetual pavement starts from Guntur region to Vijayawada via uddandrayunipalem. In the above shown map it clearly describes the route from Guntur which it is located at 16.3067 °N and 80.4365°E to Vijayawada which it is located at 16.5062°N and 80.6480° E. The distance from Guntur to Vijayawada via uddandrayunipalem is 40.3 kilometers



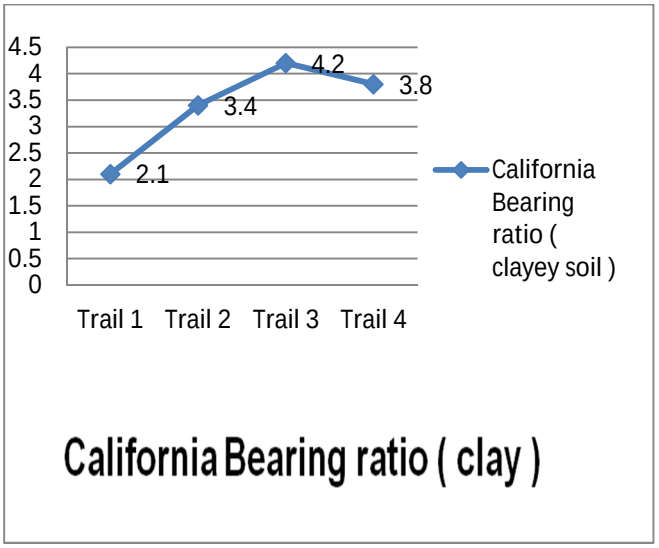
The pavement continues from uddandrayunipalem which is situated at 16.5409°N and 80.5147°E to Vijayawada 16.5062°N and 80.6480°E The distance between uddandrayunipalem to Vijayawada region is 38 Kilometers and the total distance from Guntur to Vijayawada is in 78.3 Kilometers

III. EXPERIMENTAL WORKS:

A. Sub grade layer: We have collected the soil sample from the tropical region in which the temperature varies from day to day. The mostly available soil is the clayey soil in the tropical region. So the experiments are done by taking the clayey soil. The soil sample is collected so that the sub grade layer will have certain properties like the optimum moisture content, and the California bearing ratio. The soil properties are very much for the pavement to be layed. The moisture content and dry density will have the effects on the soil. The clayey soil is the main available material in the tropical region.



Graph 1: Optimum moisture content for clayey soil



Graph 2: California bearing ratio for clayey soil

- Optimum moisture content = 18.2 %
- California bearing ratio = 4.22 %

B.BASE COURSE:

Aggregates: The aggregates from the tropical region are collected so that the tests like the effect esteem test, pulverizing esteem test, scraped spot esteem, flakiness index, elongation index, water absorption, and specific gravity tests are performed. The properties of the aggregate are to be found out so that the base course and the granular base use this aggregates in the perpetual pavements.

S.NO	Physical properties of aggregates	Test results	Maximum value (IRC)
1	Impact value test	18.2%	0-30%
2	Crushing value	22.22%	0-35 %
3	Abrasion value	29.23%	0-40%
4	Flakiness index	14.06%	Up to 15%
5	Elongation index	32.51%	30 % - 50%
6	Water absorption	0.5%	2%
7	Specific gravity	2.83	2.5-3.0

TABLE 1: Properties of Aggregates

C.BINDER COURSE: The Bitumen plays a very important role in the perpetual pavement. The base course and the binder course are layed with the bitumen. In the perpetual pavement the thickness is increased by using more hot mix asphalt (HMA). The asphalt (or) bitumen has certain properties like the penetration test, ductility, softening, fire point and flash point.

S.NO	Properties of Bitumen	Test results	Maximum value
1	Penetration	48	0-49
2	Ductility (cms)	80 cms	50-100 cms
3	Softening	48 °C	80°C
4	Fire point	220 °C	300°C
5	Flash point	240° C	250°C

Table 2: Properties of Bitumen

Marshall stability: The Bitumen is heated up to 130°C and the aggregates of different sieves are collected as GRADE- 1 according to MORTH (Ministry of road transport and highways) 5 th revision. The 1200 Gms are taken in this and the aggregate is heated up to 180°C. Then the Hot mix asphalt (HMA) is mixed with the aggregate and then maintained heat up to 130°C. It is then poured into a mould and compacted for 75 blows on both sides and later it is cooled at room temperature for 24 hours. The specific gravity tests are performed and stability is tested by the Marshall Stability testing machine. The Marshall stability is found out in this test.

Bitumen (80/100)	Wt in air	Wt in water	Flow value(mm)	Stability value (kg)	Gt	Unit wt (g/cc)	% air voids	VMA
5	1176	608.2	1.7	2080	2.25	2.07	8.69	18.7
	1182	618.1	1.9	2000		2.1	7.14	17.3
5.5	628.8	628.3	2.4	2140	2.28	2.10	6.2	17.4
	614.3	614.5	2.1	1910		2.09	6.69	17.8
6	1198	628.6	2.7	2000	2.19	2.10	4.28	16.5
	1164	612.5	3.1	2800		2.11	3.79	16.5

Table 3: Marshall Stability for the Bitumen

PROPERTIES	HMA at 130 °C
Binder (%)	5.5
Stability (kg)	1360.6
Flow (mm)	3.4
Vv(%)=100(Gt-Gb)/Gt	7
VMA% = Vv+Vb	20.2
VFB % =100Vb/VMA	65.3

Table 4: Stability of Bitumen

D.SURFACE COURSE: Crumb rubber as a binding material is used in the Bitumen and the properties are found out by using the crumb rubber at 10 % as a binding material in bitumen.

S.NO	Physical properties of Bitumen with CRMB	10% crumb rubber
1	Penetration	20
2	Ductility (cms)	28.5
3	Softening	54.5 °C
4	Fire point	260 °C
5	Flash point	280° C

Table 5: Properties of Bitumen with CRMB up to 10%

Marshall Stability test and the deformation of 10 % crumb rubber as binding material.

Experiments	10% crumb rubber
Stability (kg)	1135
Deformation (or) Flow (mm)	5.4

Table 6: Stability of Bitumen with CRMB up to 10%

III. DESIGN OF PERPETUAL PAVEMENTS BY USING SOFTWARES: The Mnpave software is designed for the flexible pavements mechanistic empirical method. It has different parameters for the flexible pavement that to be designed. The parameters are the project region and location, the climatic condition, the traffic flow at that region, and the structure up to certain layers in which the pavement must be layed. The project information like the region and location in which the flexible pavements are to be designed. We are laying the perpetual pavements in the Guntur region in which the new capital is being built. The climatic conditions which we have in Guntur district is the tropical climate so that temperature is noted in the Mnpave software. The traffic flow of the capital region of Andhra Pradesh from Guntur via uddandrayunipalem to Vijayawada is calculated according to the lifetime of 50 years and the annual growth rate is 3.8% and the traffic flow is calculated in software. As the perpetual pavement is being designed we have the layers the thickness of the layers is noted in this software.

S.NO	Type of pavement	Thickness				
		Compacted sub grade	Sub base course	Base course	Binder course	Surface course
1	Perpetual pavement	150- 300 mm	100-300mm	100-300mm	50-150mm	25-75mm

Table 7: Thickness of the perpetual pavement to be noted in Mnpave software

The design parameters for the Mnpave software are collected from the IRC 37:2012 and the design is being calculated by the software in reliability, basic and the batch mode. The design is done by the Mnpave software and the thickness is being accepted up to 7 inches.

Parameter	Value
Lane distribution factor (F)	0.70
Vehicle damage factor (D)	4.0
Traffic growth rate	7.5%
Resilient modulus of sub grade	50 Mpa
Poisson's ratio for HMA	0.5
Poisson 's ratio for GB and sub grade	0.4

TABLE 8: DESIGN PARAMETERS FOR MnPave software from IRC 37:2012

BCOA ME DESIGN is another type of software which is used to design the perpetual pavements. The design parameters for this type of approach are in the table 9.

Parameter	Value
Post milling HMA thickness (in)	6
HMA fatigue	Adequate
Composite modulus of sub grade reaction (k-value) (psi/in)	150
Flexural strength three point bending	650
Estimated PCC elastic modulus (psi)	4000000
Coefficient of thermal expansion (°F)	5.5
Fiber content (lb/yd3)	10
Joint spacing (ft)	6*6

TABLE 9: DESIGN PARAMETERS FOR BCOA ME design software

The coefficient of thermal expansion (°F) has certain values of different types of aggregates which are to be used in perpetual pavements.

Type of coarse aggregate	Coefficient of thermal expansion (°F)
Quartz	6.6
Sandstone	6.5
Gravel	6
Granite	5.3
Basalt	4.8
Limestone	3.8

TABLE 10: Recommended value of thermal coefficient of different aggregate types

The BCOA ME design performs analysis and gives the design output and recommends the perpetual pavements thickness.

Calculated PCC overlay thickness (in)	<3.0
Design PCC overlay thickness (in)	3.0
The calculated thickness is less than the minimum recommended design thickness supported by the design methodology of < 3 inches	

Table 11: Analysis performed by BCOA ME design

S.NO	Type of pavement	Thickness				
		Sub grade course	Sub base course	Base course	Binder course	Surface course
1	Conventional pavement	150 -300mm	100-300mm	100-300mm	50-100mm	25-50mm
2	Perpetual pavement	150- 300 mm	100-300mm	100-300mm	50-150mm	25-75mm

Table 12: Thickness of the pavements

IV. LIFE CYCLE COST ANALYSIS: The Life Cycle Cost (LCC) of an asset is defined as the total cost; in present value that includes the initial costs, Support, Repair and Renewal costs over the administration life or a predefined life cycle. LCC depends on an understanding that the estimation of cash changes with time and subsequently, consumptions made at various times are not measure up to. The 'time estimation of cash', is the premise for Life Cycle Cost Analysis (LCCA). LCCA is a procedure for assessing the aggregate financial expense of an advantage by breaking down introductory expenses and reduced future consumptions, for example, support, operational, client, and social expenses over the administration life or life cycle of a benefit.

S.NO	Type of pavement	Construction cost per km Rs/km	Maintenance cost Rs/km (50years)	User delay cost Rs/km	Total cost Rs/km	Total cost	% savings
1	Conventional pavement	Rs.9 crores	1 crore	1 lakh	Rs.10,01,00,000	Rs.20,01,00,000	-
2	Perpetual pavement	Rs.9.5 crores	10 lakhs	1 lakh	Rs.9,56,00,000	Rs.19,12,00,000	4.47 %

Table 13: Life cycle cost analysis of Perpetual and Conventional pavements (four lane road) for 50 years

S.No	Type of pavement	Total cost per km	Total distance kms	Total cost	10% CRMB (5% reduced)	% savings
1	Conventional pavements	Rs.20,01,00,000	78.3 kms	Rs.15,66,7 8,30,000	Rs.783 391500	-------
2	Perpetual pavements	Rs.19,12,00,000	78.3 kms	Rs.14,97,09,60,000	Rs.748 548000	4.44%

Table 14: Life cycle cost analysis of Perpetual and Conventional pavements (four lane road) for 50 years when replaced with crumb rubber

The conventional pavements that are to be laid in Andhra Pradesh from Guntur via uddandrayunipalem to Vijayawada. The distance in which that pavement that to be laid is 78.3 kms in the capital region that has tropical climate. The total cost of the conventional pavements and the perpetual pavements are compared and the best economical pavements are suggested.

V. CONCLUSION: Perpetual pavements are the long lasting pavements and its life cycle is more when compared with the normal conventional pavements. The life cycle costs are very less and they need not to be repaired often. It reduces the user delays and costs. It does not have any structural repairs which will reduce the cost. These types of pavements have long durability and have many environmental benefits. The perpetual pavements have the better resources usage and all sorts of recycling materials like the fibers; can be used as both binders and the fillers. Perpetual pavements can reduce CO2 emissions and also can reduce energy consumption. The two design software's i.e. Mnpave and the BCOA ME design software has given the design regarding the perpetual pavements and the thickness that should be established in the perpetual pavements i.e. <3 inches. The two flexible design software's are very much useful for the perpetual pavement that to be designed. The life cycle cost analysis is being analyses for both the perpetual pavements and the normal conventional pavements that are to be laid in the capital region of Andhra Pradesh from Guntur via uddandrayunipalem to Vijayawada. The distance in which that pavement that to be laid is 78.3 kms in the capital region. Its saves **4.44%** than the conventional pavements. Perpetual pavements saves lot of economy and it has the long span than the normal conventional pavements in the tropical region.

VI. REFERENCES:

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