ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

PAVEMENT ANALYSIS AND DESIGN BY VARIOUS METHODS

K.ARUN KUMAR[1], Ph.D Scholar (Highway Engineering),
DR. A.MAHESH BABU[2], Professor, Ph.D (Transportation Engineering),

[1,2]Department of Civil Engineering, Tirumala Engineering College, Bogaram(v) Keesara (M), Medchal District Telengana India.

ABSTRACT

Highway planning and pavement design plays an important role in day to day life. In our project we are calculating thickness of flexible pavement by comparing various design methods such as, Group Index method (GI), California Bearing Ratio method (CBR), Indian Road Congress method (IRC). From this design method maximum thickness is adopted for the construction of flexible pavement.

Rigid pavements are made up of Portland cement concrete, and may or may not have a base course between the pavement and the subgrade. Because of its rigidity and high tensile strength, a rigid pavement tends to distribute the load over a relatively wide area of subgrade, and a major portion of the structural capacity is supplied by the slab itself. The rigid pavements are used for heavier loads and can be constructed over relatively poor subgrade. Rigid pavement with and without base course are used in many countries all around the world.

this study presents evaluation of the techniques applied in the rigid pavement design. These including, a comparison between thickness design methods of rigid pavements by fatigue and erosion model procedure (Portland Cement Association) or PCA and empirical model procedure (American Association of State Highway and Transportation Officials) or AASHTO. Also, a comparison between new design of flexible pavement by Mechanistic- Emperical procedure (Washington Department Of Transportation) or (WSDOT) M-E and rigid pavement design is studied.

KEYWORDS : group index method(GI), California bearing ratio method(CBR), Indian road congress method(IRC), faigue and erosion model procedure , AASHTO method, Mechanistic- Emperical procedure etc .,

I. INTRODUCTION

1.1 FLEXIBLE PAVEMENT

Flexible pavement consists of several layers or component parts in which sub grade layer is the bottom layer on which the pavement is rest. Another is sub base layer which resist the capillary rise of ground water. The layer is of bolder fixed known as base coarse. Wearing coarse is the top most layer of the pavement, which expose to traffic. Also various tests are conducted on road construction material such as, aggregate, bitumen and soil. By conducting tests on soil and also by traffic volume graph we calculate a thickness of flexible pavement by GI method. By conducting CBR test in the laboratory on soil, we calculate a thickness of road. Depending on CBR percentage a thickness is determine by chart given in IRC: 37- 2001.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

Following are the material used for road construction:

1) Aggregate

2) Bitumen

A. Group Index Method:

The group index is used in the grading of soils. The higher the value of the group index, the poorer is the sub grade. Lower the value of GI higher the sub grade. In this method the thickness of the pavement is determine. The value of group index is formulated on various physical properties of soil such as liquid limit, plastic limit, etc. The group index method of pavement design is essentially an empirical method based on physical properties of the sub-grade soil. This method does not consider the strength characteristics of the sub-grade soil and therefore is open to question regarding the reliability of the design based on the index properties of the soil only.

$$\mathbf{G\ I = 0.2a + 0.005ac + 0.01bd}$$

Where,

a = that portion of material passing 0.074mm sieve, greater than 35 and not exceeding 75 percent.

b = that portion of material passing 0.074mm sieve, greater than 15 and not exceeding 35 percent

c = that portion of numerical liquid limit greater than 40 and not exceeding 60, expressed as positive whole no between 0- 20

d = that portion of plasticity index greater than 10 and not exceeding 30, expressed as positive whole on bet 0-20

B. California Bearing Ratio Method:

The CBR determination may be performed either in the laboratory, typically with a recomputed sample, or in the field. Because of typical logistics and time constraints with the laboratory test, the field CBR is more typically used by the military for design of contingency roads and airfields. The thickness of different elements comprising a pavement is determined by CBR values. The CBR test is a small scale penetration test in which a cylindrical plunger of 3 in2 (5 cm in diameter) cross-section is penetrated into a soil mass (i.e., sub-grade material) at the rate of 0.05 in. per minute (1.25 mm/minute). 8 Observations are taken between the penetrations resistances (Called the test load) versus the penetration of plunger. The penetration resistance of the plunger into a standard sample of crushed stone for the corresponding penetration is called standard load. The California bearing ratio, abbreviated as CBR is defined as the ratio of the test load to the standard load, expressed as percentage for a given penetration of the plunger.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

$$CBR = \frac{TEST\ LOAD}{STANDARD\ LOAD} X100$$

In most cases, CBR decreases as the penetration increases. The ratio at 2.5 mm penetration is used as the CBR. In some case, the ratio at 5 mm may be greater than that at 2.5 mm. If this occurs, the ratio at 5 mm should be used. The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered if high degree of reproducibility is desired. The CBR test may be conducted in re-moulded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

C. TRIAXIAL TEST

The triaxial test, when properly instrumented so as to provide complete load and deformation data, is one of the method for determining soil and rock stress-strain behavior and shear strength. Because triaxial test equipment is designed to permit separate control of both lateral and axial loadings, the test can provide data on the fundamental response characteristics of soil and rock under a wide variety of controlled states of stress. In addition to stress control, the test also permits control of loading rate, drainage conditions, and specimen size.

Separate pressure control systems are necessary for application of the several possible axial and lateral stress paths. Application of the axial lead can be accomplished by any number of methods depending on whether the test is desired to be stress-controlled or strain-controlled. When the specimen is to be loaded to failure, a strain-control method should be employed; when the behavior of the specimen is to be studied at less-than-failure stress levels, a stress-control method is preferable because of the regulation required in loading increment. Dead loading the sample, either directly or by lever systems, is probably the oldest and simplest stress control method. Pneumatic systems that apply air pressure to a movable piston can be used to develop not only very large loads (by varying the piston area ratio) but also to develop rapid loading rates. Hydraulic systems employ the same principle but are best suited for strain control testing.

D. Indian Road Congress Method:

The design related to CBR values ranging from 2 per cent to 10 per cent and ten levels of design traffic 1, 2, 3, 5, 10, 20, 30, 50, 100 and 150 msa. The pavement compositions given in the design catalogue are relevant to Indian conditions, materials and specifications. Where any change in layer thickness and specifications, the composition can be suitably modified using analytical approach with in-service performance related information and appropriate design values. For intermediate traffic ranges, the pavement layer thickness will be interpolated linearly. For traffic exceeding 150 msa, the pavement design appropriate to 150 msa may be chosen and further strengthening carried out to extend the file at the appropriate time based on pavement deflection measurements as per IRC: 81.

Flexible Pavement Design as per IRC-37-2001

Traffic Count Survey

The Calculation of vehicles is done with the traffic data and axle load survey as per IRC 37:2001. The design procedure given by IRC makes use of the CBR value, million standard axle concept, and vehicle damage factor. Traffic distribution along the lanes is taken into account. The design is meant for design traffic which is arrived at using a growth rate. Flexible pavements are considered to include the pavements which have bituminous surfacing and granular base and sub-base courses conforming to IRC/ MOST standards. These guidelines apply to new pavements.

1.2 RIGID PAVEMENT

Rigid pavements are those which possess note worthy flexural strength or flexural rigidity. The stresses are not transferred from grain to grain to the lower layers as in the case of flexible pavement layers. Rigid pavements are made up of Portland cement concrete-either plain, reinforced or prestressed concrete. The rigid pavement may or may not have a base course between the pavement and the subgrade. Due to its rigidity and high tensile strength, a rigid pavement tends to distribute the load over a relatively wider area of soil, and a major portion of the structural capacity is supplied by the slab itself. The rigid pavements are used for heavier loads and can be constructed over relatively poor subgrade i.e the subgrade with lower strength. Because of its rigidity and high tensile strength, a rigid pavement tends to distribute the load over a relatively wide area of subgrade, and a major portion of the structural capacity is supplied by the slab itself. The various layers of the rigid pavement structure have different strength and deformation characteristics. [4] presented a short overview on widely used microwave and RF applications and the denomination of frequency bands. The chapter start outs with an illustrative case on wave propagation which will introduce fundamental aspects of high frequency technology.

II.LITERATURE REVIEW

Khan et., al (1998)

He 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 soil. The curves are plotted between Group Index of sub grade and thickness for various traffic conditions. In California Bearing Ratio Method, the curves are plotted between California Bearing Ratio Percent and depth of construction.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

Arora et., al (2003)

He reported various methods for design of flexible pavements. These various methods are Group Index Method, CBR Method, California Resistance Value Method and McLeod Method. In the Group Index Method, the thickness of 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. In Mcleod Method curves are plotted between depth of construction and CBR for traffic conditions

Tarefder et. al (2010)

In this investigation present that reliability is an important factor in flexible pavement design to consider the variability associated with the design inputs. In this paper, sub grade strength variability and flexible pavement designs are evaluated for reliability. Parameters such as mean, maximum likelihood, median, coefficient of variation, and density distribution, function of sub grade strength are determined. Design outputs are compared in terms of reliability and thickness using these design procedures. It is shown that the AASHTO provides higher reliability values compared to the probabilistic procedure. Finally, the reliability of the flexible pavement design is evaluated by varying hot mix asphalt properties. Alternative designs are recommended for the existing pavement thickness by modifying material and subgrade properties to mitigate different distresses

III.RESULTS AND ANALYSIS

1. Group index of soil subgrade

Group index value

GI = (F-35)0.2+0.05(WL -40) +0.01(F-15) (IP-10)

Where F = 66%

WL = 58%, IP = 32%

⇨ GI = (66-35)0.2+0.05 (58-40)+0.01 (66-15) (32-10)

=17.51

Now from Group index vs thickness of pavement graphs

Pavement Thickness = 580mm

Thickness of Surface Course =50mm

Thickness of Base Course= 250mm

Thickness of Sub Base=280mm

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

2. CALIFORNIA BEARING RATIO TEST

Time of penetration/0.25 mm/min	Penetration I mm	Proving ring reading no. Divisions			Test load/corrected load3xvalue of one division in (kg)			Standard load in (kg) on plunger	Unsoaked/soaked CBR% 4/5x100			Average CBR
1	2	3			4			5	6			7
		I	II	III	I	II	III		I	II	III	
0.0	0.0											
0.24	0.5	9	10	10								
0.48	1.0	16	15	15								
1.12	1.5	21	20	18								
1.36	2.0	25	24	23								
2.0	2.5	28	28	27	70	70	67.5	1370	5.10	5.10	4.92	5.04%
2.24	3.0	31	31	30								
3.12	4.0	34	34	34								
4	5.0	38	37	37	95	97.5	92.5	2055	4.62	4.50	4.50	4.54%
6	7.5	43	42	44								
8	10.0	46	45	47								
10	12.50	48	47	49								

Sample = Yellow soil (Clayey silt)
2. Source of material =Quarry
3. Value of one Division of proving Ring = 2.5 Kg
Results:
Average CBR – 2.5 mm Penetration = 05.04 %

Average CBR – 5.00 mm Penetration = 4.54 %

I. 2.5 mm Penetration

CBR = Test load/ Standard load × 100%

= (28×2.5/1370) × 100 = 5.10%

5 mm Penetration

CBR = Test load/ Standard load × 100%

= (38×2.5/2055) × 100 = 4.62%

II. 2.5 mm Penetration

CBR = Test load/ Standard load × 100%

= (28×2.5/1370) × 100 = 5.10%

5 mm Penetration

CBR = Test load/ Standard load × 100%

= (37×2.5/2055) × 100 = 4.50%

III. 2.5 mm Penetration

CBR = Test load/ Standard load × 100%

= (27×2.5/1370) × 100 = 4.92%

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

5 mm Penetration

CBR = Test load/ Standard load × 100%

= (38×2.5/2055) × 100 = 4.62%

Average CBR at 2.5 mm Penetration = (I+II+III)/3 = 5.04%

TIME	HVC-Bus/Truck (Laden)			HVC-Bus/Truck (Unladen)			HVC-Bus/Truck (Overloaded)			MCV Agricultural Tractor Trailor (Laden)			MCV Agricultural Tractor Trailor (Unladen)			MCV Agricultural Tractor Trailor (Overloaded)			LCV Cars/Vans/Jeeps/Three Wheelers			HYWA(Laden)			HYWA(Unladen)			HYWA(Overloaded)		
DAY	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
7.00 to 8.00 AM	5	4	4	2	3	0	0	0	0	5	4	3	3	5	3	2	0	1	1	2	1	0	0	0	0	5	0	1	2	1
8.00 to 9.00 AM	8	3	4	0	3	0	0	0	0	6	8	3	3	6	4	3	4	1	0	2	3	0	0	1	0	0	0	1	1	2
9.00 to 10.00 AM	3	4	1	3	3	1	0	0	0	4	9	3	3	3	4	2	0	0	3	2	3	3	1	0	0	0	0	0	1	0
10.00 to 11.00 AM	1	5	5	5	4	0	1	0	0	7	3	5	3	0	0	1	12	3	1	4	0	0	9	0	0	4	1	1	1	1
11.00 to 12.00 AM	2	6	6	3	2	0	0	1	0	9	0	0	4	1	4	1	3	3	2	2	1	1	6	7	4	0	0	0	0	1
12.00 to 1.00 PM	3	2	1	2	6	1	0	0	3	1	4	7	6	0	5	5	2	2	11	2	3	3	3	0	2	0	6	1	1	1
1.00 to 2.00 PM	4	2	7	6	4	0	1	1	0	2	7	2	0	0	2	9	1	8	8	3	3	4	8	14	3	3	0	0	0	1
2.00 to 3.00 PM	6	3	3	8	9	0	3	1	1	2	5	5	9	4	4	1	0	9	7	3	3	12	5	0	10	0	4	1	1	1
3.00 to 4.00 PM	7	1	2	4	3	1	0	0	0	2	6	0	7	6	3	0	4	3	5	7	1	3	6	0	7	0	0	1	0	1
4.00 to 5.00 PM	5	6	2	2	0	0	2	1	1	5	0	6	5	3	5	0	0	7	6	6	3	4	17	0	1	2	0	2	2	2
5.00 to 6.00 PM	4	7	4	5	4	1	1	4	0	6	8	5	4	6	6	6	2	1	14	8	2	2	11	18	0	0	4	2	1	0
6.00 to 7.00 PM	6	3	6	7	2	0	4	0	2	4	0	4	3	3	2	1	2	2	16	0	3	2	6	1	0	0	6	2	2	0
7.00 to 8.00 PM	3	5	0	4	1	0	2	6	0	7	1	7	2	1	9	3	0	3	8	1	2	0	8	2	0	6	5	2	2	2
TOTAL	**57**	**51**	**45**	**51**	**44**	**4**	**14**	**14**	**7**	**60**	**55**	**50**	**52**	**38**	**51**	**34**	**30**	**43**	**82**	**42**	**28**	**34**	**80**	**43**	**27**	**20**	**26**	**14**	**14**	**13**
	51			**33**			**12**			**55**			**47**			**36**			**51**			**52**			**24**			**14**		

Calculation of Pavement Thicknesses:

Case I (Yellow soil (Clayey silt)):

Available Data:

1. Design of CBR of Sub grade Soil: 5%

2. Design Life of Pavement: 15 years

3. Annual Growth rate: 7.5 %

4. Distribution of Commercial vehicle for Single Lane: Double Lane

5. Computation of Design traffic for the end of Design life: 0.75

$N = \{365[(1+r)^{\frac{n-1}{r}}]$X{AxDxF)}

N = The cumulative no. of standard axles to be catered for in the design in terms of msa.

A = Initial Traffic in the year of completion of completion of construction in term of no. of CVPD
A = P (1+r)^x

P = No. of commercial vehicles as per last count

x = No. of years between the last count and the yearof completion of construction

D = Lane distribution factor

F = Vehicle damage factor

n = Design Life in Years

r = Annual growth rate of commercial vehicles

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

Design Calculation of Pavement thickness:

1. Commercial Vehicle at last count "P" =277CV/Day

2. r=7.50%

3. x=1

4. A=298

5. D=1

6. F=3.5

7. N=9.94 msa (say 10 msa)

8. Total thickness of pavement for design CBR 5% and Design traffic= 1 msa, of IRC 37, 2001 5% &design traffic 10msa of IRC37, 2001

Total Thickness= 660 mm

9. Total thickness to be provided = 375-150 = 225mm

10. Pavement composition interpolated as per MORT&H (IRC37-2001 page 24 plate 1)

(a) Granular Sub base= 300 mm

(b) Base course(wmm) = 250mm

(c) DBM=70 mm

(d) BC=40 mm

Total Pavement Thickness = 660mm

2. Indian road congress method

Design the pavement for construction of a new bypass with the following data:

1. Two lane carriage way
2. Initial traffic in the year of completion of construction = 400 CVPD (sum of both directions)
3. Traffic growth rate = 7.5 %
4. Design life = 15 years
5. Vehicle damage factor based on axle load survey = 2.5 standard axle per commercial vehicle
6. Design CBR of subgrade soil = 4%.

1. Distribution factor = 0.75

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

$$\begin{aligned} N &= \frac{365 \times [(1+0.075)^{15}-1)]}{0.075} \times 400 \times 0.75 \times 2.5 \\ &= 7200000 \\ &= 7.2\, msa \end{aligned}$$

2. Total pavement thickness for CBR 4% and traffic 7.2 msa from IRC:37 2001 chart1 = 660 mm

3. Pavement composition can be obtained by interpolation from Pavement Design Catalogue (IRC:37 2001).

    1. Bituminous surfacing = 25 mm SDBC + 70 mm DBM

    2. Road-base = 250 mm WBM

    3. sub-base = 315 mm granular material of CBR not less than 30 %

3. TRIAXIAL TEST

L.A.Palmer and E.S.Barber in 1910 proposed the design method based on Boussinesq's displacement for homogeneous elastic single layer:

The thickness of pavement.

$$T = \sqrt{\left(\frac{3P}{2\Delta\pi Es}\right)^2 - a^2}$$

Here T=Pavement thickness, cm

Es=modulus of elasticity of sub grade from triaxial test result, Kg/cm2

A=radius of contact area, cm

Δ =design deflection (0.25 cm)

DATA :

Wheel load=6540Kg

Radius of contact area=18cm

Traffic coefficient=1.4

Rainfall coefficient=1.0

Design deflection=.20cm

E-value of sub grade soil Es=100 Kg/cm^2

E-value of base course material Eb =350kg/cm^2

CALCULATIONS:

$$T = T = \sqrt{\left(\frac{3P}{2\Delta\pi Es}\right)^2 - a^2}$$

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

$T= \sqrt{(3*6540/2*100)^2 -18^2}$

T=1230mm

So Pavement thickness=1230 mm

Thickness of surface course =80 mm

Thickness of DBM =2500mm

Thickness of base course=300mm

Thickness of sub base=600mm

DESIGN OF RIGID PAVEMENTS.

Width of expansion joint gap=2 .0cm

Maximum variation in temperature between summer and winter=12 °c

Thermal coefficient of concrete=8 X 10^{-6} C

Allowable tensile stress in CC during curing=0.9 Kg/cm2

Coefficient of friction=1.4

Unit weight of CC=2400 kg/cm3

Design wheel load=6000Kg

Radius of contact area=18Cm

Modulus of reaction of sub base course=12.5Kg/cm^3

Flexural strength of concrete =54.2067 Kg/cm^2

E value of concrete = $4700\sqrt{fc'}$ = 30 x 10^6 kg /cm^2

Δ Value =0.14

Design load transfer through dowel system=45%

Permissible flexural stress in dowel bar=1500Kg/cm2

Permissible shear stress in dowel bar=990Kg/cm2

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

Permissible bearing stress in concrete =80Kg/cm2

Permissible tensile stress in steel=1500Kg/cm2

Permissible bond stress in deformed tie bars=28.8 Kg/cm2

Present traffic intensity=6547 commercial vehicles/day (Data collected by traffic survey)

(Note: The data assumed based on IRC-58:2002)

SLAB THICKNESS

Assume trial thickness of slab=120 cm

Radius of relative stiffness,

Eh3[I= μ/12K(1- 2]) $^{1/4}$

=[3*105*203/12*14.5(1-0.152)]$^{1/4}$

L=61.28

Lx/I=445/95.41 =4.66

Ly/I = 350/95.41 =3.66(according to I.R.C.Chart)

Adjustment for traffic intensity

Ad =P' (1+r)(n+30)

Assuming growth rate =80 %

Number of year after the last count before new pavement is opened to traffic n =3

Ad =4100 (1+ (7.5/100))(3+30) =44592.6 CV/day

So traffic intensity being in the range >6547 ,

Fall in group and the adjustment factor =+5cm

So revised design thickness of the slab =120+5 =125 cm

IV. CONCLUSIONS

The major conclusions drawn at the end of this work are as follows:

1. The thickness of crust varies with the change in the value of C.B.R. With higher value of C.B.R. the crust thickness is less and vice versa.

2. From this laboratory test it has been observed that the Yellow soil (Clayey silt) is suitable for the construction purpose for soil sub grade.

3. The pavement is designed as a flexible pavement upon a black cotton soil sub grade, the CBR method as per IRC 37-2001 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.
4. It is observed that flexible pavements are more economical for lesser volume of traffic.The life of flexible pavement is near about 15 years.

REFERENCES

[1] "Khanna .S.K & Justo C.E (March 2001)",Highway Engineering, Nem Chand & Bros Publications, Roorkee (U.A), Eighth Edition.

[2] IS 2720 Part-5 "Method of test for Soil Determination of Liquid limit and Plasticlimit".

[3] Partha Chakroborty & Animesh Das"Principles of Transportation Engineering"Ministry of Road Transport and Highways Report of the Specifications for Road and Bridge Work in India.

[4] Christo Ananth, [Account ID: AORZMT9EL3DL0],"A Detailed Analysis Of Two Port RF Networks - Circuit Representation [RF & Microwave Engineering Book 1]", Kindle Edition, USA, ASIN: B06XQY4MVL, ISBN: 978-15-208-752-1-7, Volume 8, March 2017, pp:1-38..

[5] Roy T.K., Chattopadhyay B.C. and Roy S.K., (2006). "Prediction of CBR for Sub grade of Different Materials from Simple Test". Proc. International Conference on 'Civil Engineering in the New Millennium –Opportunities and Challenges, BESUS, West Bengal,Vol.-III :2091-2098.

[6] Nuwaiwu, C.M.O., Alkali, I.B.K. and Ahmed, U.A., (2006). "Properties of Ironstone Lateritic Gravels in Relation to Gravel Road Pavement Construction". Geotechnical and Geological Engineering, 24, 283-298.

[7] Roy, T.K, Chattapadhyay, B. C and Roy, S.K. 2010. "California Bearing Ratio Evaluation and Estimation": A Study of Comparison, (Indian Geotechnical conference) IGC 2010, IIT, Mumbai, pp 19-2.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

[8] Bindra, S.P. 1991(IV–Edition). "A Course in Highway Engineering" 1991, Dhanpat Rai & Sons.

Biography

Mr. K.ARUN KUMAR, received the Master of Technology degree in HIGHWAY ENGINEERING from the NRI Institute of Technology, Village kothur(v) srisailam Highway, District Rangareddy, Telengana, he received the Bachelor of Engineering degree from Avanthi Institute Of Engineering & Technology. He is currently working as Assistant Professor in CIVIL with Tirumala Engineering College.

Email id: kandukuri116.arun@gmail.com.