All weather road access biology essay

Science, Biology

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Abstract

The development of rural areas is unthinkable without provision of All Weather Road access to all our villages and habitations. Government of India has undertaken massive programme of rural connectivity under the Pradhan Mantri Gram Sadak Yojana (PMGSY). CBR method is very common method used for design of rural road in India. The design chart showing the relation between rural road thickness and number of cycle taken by the pavement for given four days soaked CBR value of subgrade soil is given in IRC: SP: 72-2007 But the major drawback of CBR test is that it is penetration test and maximum penetration of plunger is as high as 12. 5 mm which may not realize in actual practice. Considering the above mentioned drawback it is urgent need to develop mechanistic-empirical pavement design approach for design of low volume rural roads. This methodology should have capability to characterization of different materials properties, loading conditions and has ability to evaluate design alternatives on economic basis. The Triaxial test was conducted on subgrade soil-A and soil-B as well as other pavement layers of low volume rural road at a confining pressure of 40 KPa . These stress-strain data used as an input parameters in finite element modeling. The results of finite element modeling were utilized for evaluation of number of cycles taken by low volume rural roads. Key words: Finite Element Analysis, Rural Road, Abaqus.

1. Introduction

The rural roads are the basic infrastructures required for the development of rural areas. Rural roads have been planned and constructed under various Rural Development Programmes of the Government of India. Many of technical aspects of road making were never making due importance rural roads; e. g. adequate compaction of subgrade, drainage, required cross drainage. There are plenty of appropriate technologies for rural road construction and maintenance using locally available materials as well as local agricultural implements. Continued emphasis was laid in all the nine Five-Year Plans on village connectivity with an aim of achieving 100 percent road connectivity to all villages by the turn of century. Over these plans, substantial development has taken place in the expansion of rural road network. However there has been admittedly neglect in proper maintenance of rural roads after their construction in the absence of uniform guidelines. The rural roads continue to suffer from the lack of uniform standards also because of the fact that a number of agencies in the state have undertaken rural road construction under various schemes.

2. Literature Review

Kerkhoven and Dormon (1953) suggested the use of vertical compressive strain on the surface of subgrade as failure criterion to reduce permanent deformation; Saal and Pell (1960) recommended the use of horizontal tensile strain at the bottom of the asphalt to minimize fatigue cracking. The use of the above concepts for pavement design was first presented in the United States by Dormon and Metcalf (1965). The use of vertical compressive strain to control permanent deformation is based on the fact that plastic strains are proportional to elastic strain in paving materials. Thus, by limiting the elastic stains on subgrade, the elastic strain in other components above the subgrade will also be controlled; hence the magnitude of permanent deformation on the pavement surface will be controlled in turn. These two criteria have since been adopted by Shell Petroleum International (Claussen et al., 1977) and by the Asphalt Institute (Shook et al., 1982) in their mechanistic- empirical methods of design. The advantages of mechanistic methods are the improvement in the reliability of design, the ability to predict the types of distress, and the feasibility to extrapolate from limited field and laboratory data. Boussinesq elastic theory was the basis for all methods in this group as it gave the stress and displacements at any point within the solid due to point load acting normal to the surface . Burmister (1943) developed the layered theory for analysis, which is considered more general than the Boussinesq's theory. If layers of soil subgrade, sub-base and base courses are assigned elastic moduli of Es, Esb, Eb respectively, then these are considered equal (Es = Esb = Eb) in Boussinesq analysis whereas in Burmister's analysis, Es < Esb < Eb. Prashant P. Nagrale et al (2005) demonstrated behavior of flexible pavements resting on unreinforced and fibre reinforced subgrade soils. They reported for constant other parameters. There is considerable reduction in vertical compressive strain at top of reinforced subgrade. It leads to reduction in layer thickness of pavement or extension in service life. Rahman M. T., Mahmud K., Ahsan S. (2011) reported that Abaqus, a finite element modeling program has been widely applied for pavement analysis. Zaghloul and White (1993) simulated the pavement response using Abaqus.

3. Experimental Program: Material Selection for Subgrade and other Pavement Layers:

Two types of soils are selected in present study. These types of soils are available in most of the part of India. The laboratory test was carried out on the selected subgrade soil for its classification. The soil- A is clay soil and soil -B is fine sand. The various properties of soils used in present study are shown in Table 1.

Table 1: Physical properties of subgrade soil (Prashant P. Nagrale, 2005)

Sr. No.

Properties

Soil-A

Soil-B

1Dry density(KN/m3)16. 9019. 302OMC (%)17. 0011. 403Specific gravity2. 162. 404Four days soaked CBR (%)1. 1665Coefficient of uniformity

-

2. 646Coefficient of curvature

-

1. 217D50(mm)0. 110. 338Lquid limit (%)34. 00

-

9Plastic limit (%)22NP10Plasticity Index12. 00

-

11Unified soil classificationCLSM12AASHTO classificationA-6A-313Typical nameClay soilFine sand14E-value(Mpa)7. 5616. 21Chandra and et. al (2008) reported that the effect of lateral confinement due to shoulder and other pavement layers in the range of 0. 26 to 0. 40 kg/cm3, hence triaxial test were conducted on different pavement layer materials and the value of initial tangent modulus at a confining pressure of 40 KPa for different pavement layer materials, the same value adopted for Finite Element Modelling of Low Volume Rural Road in present study. Table 2 shows the value of initial tangent modulus and Poisson's ratio for other pavement layer materials after Chandra et. al (2008).

Table 2: Value of Initial Tangent Modulus of Other Pavement Layers (Chandra et. al 2008)

Subbase

Base

Surface Course

E-value(MPa)70. 1299. 20269. 70μ-value0. 30. 30. 50The present study is concentrated on the development of design charts for low volume rural roads. The Indian Practice Code IRC 37-2001 and IRC: SP: 72-2007 are used as standard for designing. These practice code uses four days soaked CBR value of subgrade soil for design. Also suitability of aggregate for different layers of low volume rural road decided based on Abrasion, Impact and Crushing Value. e. g. The crushing value of aggregate is less than 45 can be accepted as a subbase material if there are two aggregates, aggregate-A having crushing value 45 and aggregate-B having crushing value 10. As per the guidelines both these aggregate can be used as a subbase material but looking to properties Aggregate-B is stronger compared to Aggregate-A and if Aggregate-B is used as a subbase material in low volume rural road pavement may be overdesigned. Unnecessary there is wastage of Aggregate. Keeping in view the above mentioned drawbacks of existing methods the mechanistic –empirical pavement (M-E pavement) design approach for design of low volume rural roads is used in present study. This methodology has better capability to characterization of different material properties and loading conditions and has ability to evaluate different design alternatives on economic basis.

4. Finite Element Analysis

Finite Element Analysis is computer simulation technique used in engineering Analysis. It uses numerical technique called Finite Element Method (FEM). The FEM based on principle of discretization and numerical approximations to solve scientific and engineering problem. It uses complex system of points called " Nodes" which makes a grid called " Mesh". This mesh is programmed to contain the material and structural properties which define how structure will react with certain loading conditions. The rural road pavement section is modeled as per IRC: SP: 72-2007 for a traffic intensity of 0. 6 msa to 1 msa using Finite element modeling software ABAQUS. The thickness of various layers for CBR value of subgrade soil A and Soil-B are presented in Table 3. IRC -37 -2001 recommended that if the CBR of subgrade soil is less than 2 % , the design should be based on CBR of 2 % and a caping layer of 150 mm should be provided in addition to sub-base thickness . Hence caping layer of 150 mm has been taken in addition to sub-base thickness for pavement section resting on subgrade soil-A.

Table 3: Thickness of Various Layers (As Per IRC: SP: 72-2007)

Layer

Width

(m)

Thicknesss (m)

Soil - A

Soil - B

Bottom (Subgrade)0. 2400. 5000. 100Sub base (Above subgrade)0. 240(0. 300+0. 15= 0. 450)0. 200Base (Above Sub base)0. 2400. 1500. 150Surface Course(Top)0. 2400. 0750. 075(Note.:- 0. 15m caping layer as CBR less than 2% for soil-A.)Figure 1 shows the dimensions of stanadard section of low volume rural road resting on subgrade soil-A for the application of finite element method in pavement analysis. The layer system of infinite extent is reduced to an approximate size with finite dimensions. The right hand and left hand boundary from the outer edge of loaded area provided at a distance of 1050 mm which is more than 5 times the loaded area. A pressure equal to single axle wheel load is assumed to be applied at surface and distributed over a circular area of diameter 300 mm; it comes to be 5. 75 kg/cm2. jg1[1]

Figure. 1 Standard Low Volume Rural Road Pavement Model Resting on

Subgrade soil A (SP: 72-2007).

5. Evaluation of Benefits:

IRC-37: 2007 proposed two failure criteria fatigue defined as the number of cycles required to produce a fatigue crack of 20 % at pavement surface is inversely proportional to horizontal tensile strain developed at the bottom of bituminous layers presented by fatigue equation, NF = 2. 21 * 10-4 [1/ εt] 3. 89 [1/ E] 0. 854 (3)Where, NF = Number of cumulative standard axles to produce 20 per cent cracked surface areaεt = Tensile at the bottom of BC layer (micro strain)E = Elastic modulous of bituminous surfacing (MPa)Whereas rutting defined as the number of cycles required to produce a rutting depth of 20 mm at pavement surface is inversely proportional to vertical compressive strain developed at top of subgrade and presented by rutting equationNR = 4. 1656 * 10-8 [1/ εv] 4. 5337 (4)Where, NR = Number of cumulative standard axles to produce rutting of 20 mmεv = vertical Compresive strain at top of Subgrade (micro strain)In the present study rutting is used as failure criteria to evaluate the number of cycles taken by the pavements and discussed in subsequent sections.

6. Benefits in terms of Reduction in layers:

The low volume rural road resting on subgrade soil A and soil B was modeled as per IRC SP: 72-2007 vertical compressive strain developed at the top of subgrade was captured. Table 4 shows the variation of Vertical compressive strain at top of Subgrade with change in subbase thickness for constant Base (150 mm) for and variation of vertical compressive strain at top of Subgrade with change in base thickness for constant sub base (450 mm) for Pavement resting on subgrade soil – A. Similar exercise is done for the pavement resting on subgrade soil-B and presented in Table5. Study shows that the vertical compressive strain consistently decrease with decrease insubbase thickness for constant base or decrease in base thickness for constant subbase. When pavement is modeled as per SP: 72: 2007 for traffic of 1 msa thickness of subbaseand base required is 200 mm and 150 mm respectively but the same pavement may betake more number of cycles. The exact thickness of subbase or base course need to beprovide above the subgrade soil-A and soil-B for a traffic intensity of 1 msa can bedirectly read out from Table 4 and Table 5.

Table 4: Variation of Vertical Compressive Strain at top of Subgrade and Number of cycles with Change in subbase thickness for constant Base (150 mm) for Pavement resting on subgrade soil – A

Subgrade Soil-A

Variation of εv at top of Subgrade and Ns with Change in subbase for constant Base(150 mm)Variation of εv at top of Subgrade and Ns with Change in Base for constant Subbase (450 mm)

Subbase Thk.(mm)

Vertical Strain(εv)(Micro)

Ns

Base Thickness

Vertical Strain(εv)(Micro)

Ns

450448. 756. 282150448. 756. 282425478. 754. 691125481. 244. 580400511. 383. 477100516. 783. 315375546. 962. 56175555. 712. 382350573. 572. 07450598. 321. 704325617. 381. 48125613. 301. 523300665. 301. 0540690. 160. 893275717. 830. 747

Table 5: variation of Vertical Compressive Strain at top of Subgrade and Number of cycles with

Change in Base thickness for constant Base (150 mm) for Pavement resting on subgrade Soil–B

Subgrade Soil-B

Variation of εv at top of Subgrade and Ns with Change in subbase for constant Base(150 mm)Variation of εv at top of Subgrade and Ns with Change in Base for constant Subbase (200 mm)

Subbase Thk.(mm)

Vertical Strain(εv)(Micro)

Ns

Base Thickness

Vertical Strain(εv)(Micro)

Ns

200607. 581. 591150607. 581. 592175644. 451. 291125646. 581. 198150683. 480. 933100688. 480. 903125768. 170. 71675733. 440. 676The value of vertical compressive strain developed at the top of subgrade is furtherutilized for evaluation of number of cycles and presented in Table 4 and 5The vertical compressive strain developed at the top of subgrade found to be 448. 75 micron and number of cycles taken by the pavement is about 6. 282 msa. If we reduce the thickness of subbase from 450 to 300 mm, the number of cycles taken by the pavement is 1. 054 msa. Similarly if we reduce the thickness of base from 150 mm to 50 mm, for constant subbase (450 mm). The number of cycles taken by pavement is 1. 70 msa. It indicates if the designer is provide the thickness of the pavement as per SP: 72-2007(0. 6 to 1 msa) . The life of pavement may be much more (6. 28 msa). If he reduce the thickness of pavement layer there is considerable saving in materials.

6. Conclusions:

The finite element model was developed to mechanistically solve the layers pavementresponse of low volume rural roads in order to evaluate the structural benefits ofmechanistic approach compared to conventional practices in pavement design andfollowing findings are observed: i) The study shows that vertical compressive strain consistently increase with decrease inthickness of subbase for constant base in both pavement type-A and type-B. ii) The value of vertical compressive strain at top of subgrade soil-A and soil-B forstandard section as per SP: 72: 2007 is found to be 448. 75 µ and 607. 58 µ respectively. iii) The value of vertical compressive strain at top of subgrade soil-A increase from448. 75 micron to 665. 30 micron. When subbase thickness reduced from 450 mm to300 mm and constant base of 150 mm. iv) The value of vertical compressive strain at top of subgrade soil-B increase from607. 58 micron to 683. 48 micron when subbase thickness reduces from 200 mm to150 mm and constant base of 150 mm. v) The pavement resting on subgrade soil-A and soil-B is designed as per SP-72-2007for a design traffic of 0. 6 msa to 1 msa, considering rutting as failure criteria. Thesame pavement section resting on soil-A and soil-B will take 6. 283 msa and 1. 59 msa. vi) For constant subbase (450mm) thickness of base reduced from 150 mm to 25 mmfor pavement resting on subgrade soil-A, it indicates that there is considerable savingin material as well as cost effective.