2019 RESEARCH SYMPOSIUM

RESEARCH & DEVELOPMENT DIVISION
ROAD DEVELOPMENT AUTHORITY

Abstracts

WEIGHTED PLASTICITY INDEX (WPI) AS A SCREENING TOOL FOR QUALITY CONTROL MEASURES

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Background

Expansive soils are one of the most problematic materials in road construction. Soil expansiveness is generally assessed by the Plasticity Index (PI) test. But PI test discards the fraction coarser than the 425µm test sieve as part of the test procedure. Therefore PI test does not well represent the whole sample. In Sri Lanka, residual soils are very common, with a high granular content in "clayey" soils. Therefore PI value often provides error in classification of residual clays.

Introduction

Weighted Plasticity Index (WPI) is another parameter which can be used to assess the expansiveness of the soil. WPI is defined as the product of the PI and the percentage passing in the 425µm test sieve. Therefore WPI is accounts for both PI and percentage used in the test.

Objectives

The objectives of the study are to find out correlations to WPI with soil CBR and CBR swell and then establish the WPI boundaries for soil materials such as embankment soil, shoulder soil & sub-base soil.

Methodology

Soil data on different soil samples were collected and analyzed to find out above mentioned correlations.

Results

A best fit linear correlation was obtained for CBR swell & WPI and is shown in the Figure 1 below.

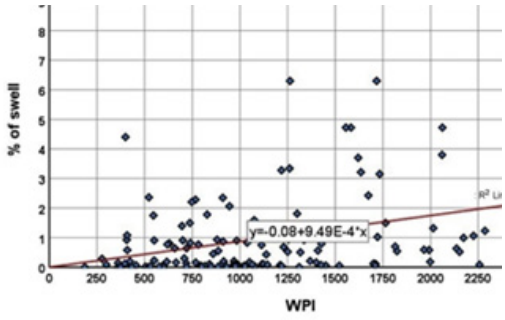


Figure 1: Relationship between CBR swell & WPI

A soil classification method is developed for the subgrade soil based on the correlations obtained from the data analysis carried out and is given in the table 1 below.

Table 1: WPI Classification for subgrade soil

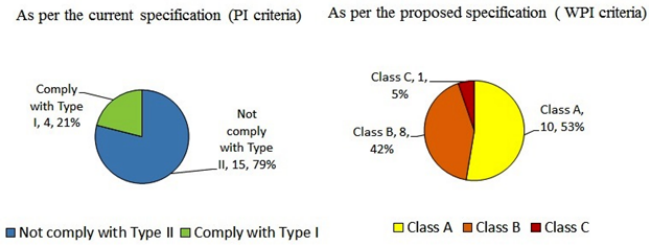
Soil Class	WPI	CBR Swell	Potential for Volume change
A	<1100	<1%	Low
B	1100 ≤ WPI<2250	1% ≤ CBR swell<2%	Medium
C	≥2250	≥2%	High

Case study

Further a case study was done using the soil data collected from the Outer Circular Highway (OCH) phase III project in order to validate the above mentioned WPI boundaries for subgrade soil.

Soil samples were classified using the classification method based on the PI and the proposed classification based on the WPI and is graphically shown in the Figure 2.

Figure 2: Comparison of soil classification



The project had the bulk quantity of cut section soil and wanted to use it for their embankment construction. But the soil classification based on the PI is expressed that the soil is not suitable for the embankment construction. However the soil classification based on the WPI shows that the 95% of soil can be used as the embankment material.

Findings

Soil classification based on WPI provides meaningful solution to overcome the misclassification arises in PI test due to the usage of percentage passing in the 425µm test sieve. Also WPI classification leads to significant savings while qualifying significant quantities of marginal material for road construction.

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RELATIONSHIP BETWEEN W/C RATIO AND THE COMPRESSIVE STRENGTH OF CEMENT CONCRETE

H. W. P. K. Jayarathne[1]

Abstract

Basically, in Sri Lanka, mostly used method of designing the normal concrete mixes is the method described in the publication of BRE together with TRL and the British Cement Association. The major factors considered for providing required type of concrete mixers are Cement Content and Free Water Content which governs the Strength, Workability and the Durability. Additionally, guides have been given for the size, gradation and the relative densities of aggregateused for concrete. The basic guidance consists of information and data gathered empirically, have been given in forms of Tables and Graphs for the convenience of the user. From these information, it can be determined the Free Water Content, W/C ratio, Cement Content, Wet Density of Concrete and the Percentage of Fine Aggregate which required to finalize the Mix proportions of ingredients. Among the above mentioned parameters, it can be seen that the W/C ratio is a major factor which governs the Strength of concrete and in the other hand this restriction help to enhance the durability of concrete. Relationship between the Water to Cement Ratio and the Compressive Strength, which is based on 0.5 W/C ratio as a guide, is given in the Figure 4 of the publication.

However, past experiences has proved that the above relationships cannot be used directly to produce the required concrete under local conditions. Specially, the relationship between W/C ratio and the Compressive Strength curves cannot be used directly without modifications. This may be due to differences of locally available materials, environment, workmanship and other conditions. However, to overcome these deficiencies if the modification can be done accordingly, it will be useful for local technicians and the Engineers.

Therefore, the aim of this study is to modify the relationship between the W/C ratio and the Compressive Strength which is suitable for local conditions.

Procedure

The main target was to find the relationship between the W/C ratio and the Compressive Strength of concrete. Therefore, Trial mixes were carried out using different W/C ratio in between 0.36 to 0.56, remaining the Free Water Content unchanged. The following restrictions were adopted during the process.

1. To determine the fine aggregate proportion, blending in to the all in aggregate grading bands was adopted (not based on the 600μm sieve passing %)
2. It was considered the workability as medium (slump = 30mm – 60mm)
3. No admixture was used.
4. The Margin was considered as 10 N/mm2 (where necessary)
5. Other parameters were abstracted from the BRE publication.

The following cement brands were used for trial mixes.

1. Ultratech OPC
2. Tokyo Super OPC
3. Insee Ready Flow

Trial mixes are carried out using different batching plants such as

1. CATIC Engineering batching Plant, Kegalle.
2. Orient batching Plant, NuwaraEliya.
3. Hunan Construction batching Plant, Udupussellawa.
4. WKK batching Plant, Welimada.

The all possible data were gathered during the process. Mainly, the Slump, initial Temperature of Mixes, Compressive strength after 7 days and 28 days curing, curing temperature etc. were measured.

Results

Mainly, analyses were carried out on the compressive strength at 7 days and 28 days against the W/C cement ratios. First, analyses were done base on the brand of cement and the batching plants. Finally, average compressive strength at the age of 7days and 28 days were analyzed considering all the compressive strength results available and determined the relationship with the W/C ratio statistically. Nonlinear relationship was

observed from the analyzed data and a formula was determined to represent the relationship by regression method.
The final results can be summarized as follows.

W/C ratio	0.36	0.38	0.4	0.42	0.44	0.46	0.48	0.5	0.52	0.54	0.56
Compressive Strength at 7 days (N/mm^2)	41.0	36.5	32.0	27.0	23.0	20.5	18.0	15.0	13.5	11.0	9.5
Compressive Strength at 28 days (N/mm^2)	60.5	54.0	47.0	41.0	36.0	32.0	27.0	22.0	18.0	16.0	13.0

Formula

For 7 days – $f_{cu} = 588.44\, e^{(-7.327w/c)}$

For 28 days – $f_{cu} = 1032.9\, e^{(-7.712w/c)}$

Where,

f_{cu} = Target Compressive Strength

w/c = Water Cement Ratio

Conclusion

It was observed that the curves obtained from the study under local conditions are significantly different with respect to the curves produced in the Figure 4 of the publication. Even the shape of the curve also shows slight variation. However, a few trials were carried out using the new formula at some batching plant and completed with successful results. However, it is expected to extend the study on controlling with higher workability with the help of admixtures and its behaviors.

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EVALUATION OF RHEOLOGICAL PROPERTIES AND PERFORMANCE OF ASPHALT BINDER MODIFIED WITH NANO CLAY

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Abstract

The rheological behavior of bitumen is very complex and it can be varied from purely viscous to elastic depending on the loading time and the temperature. Bitumen plays a major role in many aspects of road performance. Various investigations have been carried out related to the modified bitumen to improve the performance of bituminous mixtures. Many of the roads have failed due to the rutting and cracking of the bituminous layer which is due to the mostly poor performance of bituminous binders. So, the modification of the bitumen has been a major approach today and modified bitumen is effectively used in many countries during last three decades to construct the road pavements. This research present a laboratory scale evaluation of the conventional and the fundamental rheological characteristics of modified binders with nano clay contain 2%, 4%,6% & 8% by its weights.

Engineering fields are widely used montmorillonite (MMT) nano clay for wide range of applications. In Sri Lanka also, there had been few researches about the usability and characterization of MMT clay which is available at a clay deposit in Mannar area near to the Giant Tank. The clay powder prepared from the original samples taken from the above area and it was added to the original bitumen of 60/70 penetration grade binder to prepare the modified binder. The prepared clay powder was subjected to the X- ray diffraction to identify the MMT clay.

Modified bitumen samples were prepared by adding nano clay mixed at 1600C with the mixing time of 25minutes. The properties of the modified binders with nano clay were evaluated in terms of their properties using penetration, softening temperature, ductility and dynamic viscosity tests. Finally modified bitumen of each samples was evaluated for the rutting and fatigue resistant for fresh and aged samples with the Dynamic Shear Rheomoter (DSR) test.

It was observed by the results obtained from the tests that the softening point and viscosity increased up to 4% clay, penetration and ductility has decreased with increasing of clay percentage. Rutting resistance has been improved with compared to conventional bitumen and but it was showed that modified bitumen and original samples were showed PG 70 grade with 2%, 4%, 6% and original bitumen sample. There was no much effect for changing the fatigue resistance with compared to the conventional bitumen. Finally few samples of modified binder with nano clay were checked with Furrier Transform Infrared Spectrometer (FTIR) to identify any chemical changes with compared to the conventional bitumen.

As a conclusion from these findings that is the monmorillonite clay modification helped to improve some characteristics of the bitumen binders. But at this level they are not at the stage to verify application at large scale

KEYWORDS: Nano clay, Montmorillonite, Viscosity, Penetration, Softening point, Dynamic Shear Rheometer

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USE OF WASTE POLYTHENE IN ROAD CONSTRUCTION

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Abstract

In Sri Lanka the use of plastic products increases rapidly day by day. The management of waste plastic collecting at dumping yards is major problem facing by the Local Government Authorities. Sri Lanka generates 794 tons of plastic waste per day.

The aim of this paper is to examine the possibility of using waste polythene in road construction work as to provide a sustainable solution for waste polythene management in the country. In the researchmoreattention has not beenpaid to improvement of asphalt concrete but to maintain the quality standard of road and mix parameters according to the RDA specification while finding a solution for waste polythene management.

In the research study 0.2% to 2.5% of shredded waste polythene wasadded by weight of aggregate in asphalt concrete mix. A control mix and 04 trial sets of Marshall Specimens with deferent waste polythene content were cast. Suitable ranges of 0.2% to 0.8% polythene content by weight of aggregate were found. It was observed that reasonable improvement of Marshall Stability parameter and others are within the specification limits.

The Responsibility of production and paving of this waste polythene added asphalt concrete were taken over by the local contractor and RDA provided a suitable section of road at Borupana Road at the vicinity of R&D division. A Marshall Mix design of waste polythene added was carried out by the contractor with guidance of R&D Division to suit the aggregate available in the asphalt premix plant. Cross checking of asphalt concrete mix design was done by R&D Division and it was found that the parameters are within the range the waste polythene content of 0.3% by weight of aggregate and the binder content is 4.3%. It is already nine months over for the research trial section and observation are being made by R&D Division. The first observation was made by at the age of 06 months by evaluating the surface condition by measuring the skid resistance and the sand patch test for surface texture and it was found the values are within the spec limits. Visually observed the formation of any cracks and no cracks were appeared.

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MEASUREMENT OF ROAD SURFACE UNDULATIONS USING A LOW COST ACCELEROMETER SENSOR

A.W.C. Chamikara[1],Dr H.R Pasindu[2]

Abstract

International roughness index (IRI) is the main parameter that measures the comfortability of using a road. This index is also taken as a thumb rule when taking the road maintenance and rehabilitation decisions. Main problem of this method is the high cost of the equipment required. Low cost alternatives like travelling beam methods are time and labour intense compared to the IRI measuring device. There are numerous research has been done on the use of built-in smart phone accelerometer to determine the IRI value as a low cost alternative.

Aim of this research is to improve the accuracy of the measurement using a low cost off the shelf accelerometer without compromising the cost aspect. In this method, accelerometer is fixed to the axle of a vehicle and get the data via bluetooth to a smartphone. Since the measurement is not damped by the shock absorbers of the vehicle, the readings are much more realistic. A machine learning algorithm is used to analyse the collected data and predict the road condition. This algorithm should be trained using a training data set prior to the use. This process involves to collect and label data according to the prior knowledge and available data. This was done by first collecting data using a smartphone application while manually labelling the data points. Then this data was separated as training and testing data as appropriate and training data was fed into the algorithm with the manually labelled data as a reference. After training the algorithm, testing dataset was fed to the model.

Second part of the research was carried out to train the algorithm on detecting potholes without human involvement. For this, the data collection application was slightly modified to label the pothole data points. Then the previous training and testing method was carried out.

Accurate results were observed during both instances with reference to the labelled data. It was observed that the more training data makes the prediction model more accurate.

Since this is a low cost method to determine the road surface condition, local road authorities can implement this as a network to collect real time data and carryout the future road maintenance works effectively.

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IMPROVEMENT OF NIGHT TIME VISIBILITY & SKID RESISTANCE OF ROAD PAVEMENT MARKINGS TO SUIT SRI LANKAN WEATHER CONDITION

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Abstract

Pavement markings play an important role to improve road safety and better road network to meet the social aspiration of the people by providing visual guidance to motorists. In order to function properly, pavement markings must be visible under all weather conditions & to any ages of drivers. In general, most pavement markings provide satisfactory performance under dry conditions. However, under wet night conditions, the visibility of these materials degrades significantly as the marking surface becomes flooded with water, leading to partial or complete disappearance of the marking.

Currently Sri Lanka use thermoplastic paint for road marking with intermix & drop on glass beads in order to give the retroreflection for night time visibility. However wet night visibility of these material is in low lwvwl as these conventional glass beads have a refractive index ranging from 1.5 to 1.9. To be able to reflect in wet weather condition a higher refractive index is needed (Paul J.Carlson, 2007)

Therefore, this study was focused to evaluate the performance of thermoplastic road marking paints applied with ceramic beads which has refractive index over 2.4 and evaluate the improvement of visibility (especially night time retroreflectivity under wet condition) & skid resistance values.

At the initial stage, retro reflectivity (dry & wet) was measured for newly applied road marking on several locations to get the idea about current values, and it has been seen lower values in wet condition.

Then laboratory investigations were carried out to evaluate the variation of retroreflection values & skid resistance by varying the amount of glass beads, 250 g/cm2 to 400 g/cm2. It could be seen that retroreflection could be improved upto certain level and increasing glass beads beyond this will result to reduce the skid resistance value.

Then a field trail was done with ceramic beads to study the improvement in visibility. In this study road marking was applied on Kotte-Bope Road (B240) over the pedestrian crossing and night time visibility in dry & wet conditions and skid resistance were evaluated over 9 months.

High values (622 $mcd.m^{-2}.lx^{-1}$ - dry & 420 $mcd.m^{-2}.lx^{-1}$ – wet) of initial retroreflectivity & (85) skid resistance were obtained from the section which was applied with ceramic beads. But deterioration was observed in this section compared to the conventional glass bead section. Reason to this was identified as a discoloring due to tire marks which resulted from high rate of vehicle movements on pavement markings.

Therefore, further performance evaluation is needed to carry out on center lines and edge lines for highway and expressway sections which have low vehicle movements on markings.

As conclusions, ceramic beads could be used to gain high retroreflection and we need to introduce & implement quality control checking of retroreflection under wet condition and introduce these high quality materials to gain high visibility. Also these retroreflectivity values should specify based on type of roads (highways, Expressways) to be visible under all weather conditions & to all persons because speed of the vehicle & age will determine the most prominent factors to visibility of these markings.

KEYWORDS: Thermoplastic Pavement Marking, Night time visibility, Skid resistance, Glass Beads, ceramic Beads

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PRACTICAL CONSTRUCTION DEFECTS OF BORED CAST-IN-SITU PILES

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Abstract

Pile foundations have been used as load carrying and load transferring system for many years. In the early days of Civilization from the communication defence strategic point of view villages and towns where situated near to rivers and lakes. It was there for important to strengthen the bearing ground with some form of piling. Timber piles driven into the ground by hand of holes were dug and filled with sand and stones. In 1740 Christopher Polhem invented pile driving equipment which resembled to days pile driving mechanism. Steel piles have been used since 1800 concrete pile since about 1900. The industrial revolution brought about important changes to pile driving system through the invention of steam and diesel driven machines. more recently, the growing, construction activity especially of high rise buildings and bridges increase significantly in Sri Lanka, resulting in an increase in demand for the construction of bored cast in situ piles to exploit land with poor soil characteristics. This has led to the development and improved piles and pile driving systems. Today there are many advanced techniques of pile installation.

As for driven piles, protests on noise pollution have been the major factor pushing its use to more isolated locations.

Sri Lanka has witnessed a very rapid growth in the construction of bored in situ piles using the rotary drilling machines and also in conventional precussion chisel boring that is being successful adopted to the relatively smaller projects.

This paper analysis and describes the defects reported by CSL and PDA test data for some bored cast in situ piles constructed using the rotary drilling machines and also in conventional precussion chisel boring in a site in newly and reconstruction of bridges and RDA MFAP division bridge packages. The analysis of the defects leads to the conclusion that this defects were mainly due to the improper construction practice and also due to improper identification of the bearing stratum. There may be genuine difficulties in identifying the bearing stratum when both drilling procedures is adopted in the construction. The construction Robbins do not always specify the bearing conditions and the methods for ensuring such bearing condition. The conclusions are applicable to several such cases recently experienced in construction, even though they are not reported and analysed with an open mind. the paper course for corrective measures to overcome such defects in the forthcoming new projects.

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STUDY OF FAILURE OF ASPHALT CONCRETE ON ROAD PAVEMENT BY FORMING CORRUGATIONS AND HUMPS

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Abstract

In the context of flexible pavement, the uppermost black top called Asphalt Concrete (A/C) wearing surface is much more important component since, it provides a smooth riding surface for the motorists and its main function is to provide a safe and comfortable riding surface to traffic. In addition, it is expected to protect water infiltration to the layers beneath.

Increasing numbers of new roads in Sri Lanka are being rehabilitated with A/C surfacing courses with thick layers to accommodate the present traffic volumes. However, it was observed that large movements that is corrugations and humps on A/C surface have been occurred even on newly paved roads.The study is mainly concerned to identify the reason for these distress modes of A/C surfacing and propose solutions to minimize them.

In this study the effects of aggregate gradation, level of compaction, Marshall parameters such as VIA and VMA, design Asphalt content on A/C mixers were considered in the laboratory study and A/C core samples were collected on corrugated and regular road surface and their bulk densities, percentage of binder, percentage of dust passing 75µm sieve, fineness modules and Marshall parameter such as VIA and VMA were analyzed in the field study.

The results of the study revealed that the main reasons for failure of A/C surfacing by forming corrugations and humps is due to high percentage of Asphalt binder and dustpassing 75µm sieve in the A/C mixture and less air voids in the A/C mixture.

The problem can be minimized if voids in the mix retained at least more than 3% after secondary compaction by traffic and a method should be adopted to avoid over compaction of Asphalt Concrete mix at laying site and also reducing the asphalt binder further from the designed value without violating the Marshall parameters for slow moving heavy traffic pavements.

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LABORATORY SIMULATION OF COMPACTION OF BITUMINOUS CONCRETE MIX FOR REFUSAL DENSITY CRITERIA

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Abstract

Several discussion are going on evaluate the validity of designing the hot mix asphalt(HMA) mixes using the Marshall method for heavy duty pavement. The density and particle orientation of aggregate obtained during the Marshall test does not represent the ultimate condition and density in the road pavement due to subsequent after compaction by slow moving heavy vehicles.

This paper describes an improved of method of design which is also sustainable & focusing towards. The resistance to deformation at high temperatures and heavy loadings.

Refusal density concept is another method of designing HMA mixes especially for heavy duty pavement. The refusal density of bituminous mixes needs to be determining accurately to predict the life of pavements subjected to heavy traffic while maintaining 3% voids in the mix.

The study indicates that failure by plastic deformation in well graded mixes can occur very rapidly once the voids in the mix (VIM) are below 3%. To be sure that in situ VIM never drops below 3% an additional test procedure in which samples are compacted to refusal condition until they refuse to become any dense.

The binder content corresponding to 6 per cent VIM obtained in the Marshall test is noted and additional test samples prepared at each of three binder contents, namely the binder content corresponding to 6 percent VIM and also binder content which are 0.5 percent above and 0.5 percent below, this value. These samples must be compacted to refusal.

The number of blows required to produce a refusal condition will vary from one mix to another. It is preferable to conduct a trial using the lowest binder content and to compact using an increasing number of blows, say 200, 300, 400 etc. until no further increase in density occurs. Usually 500 blows on each face is found to be sufficient.

In the vibrating hammer method, the samples are compacted in 152-153mm diameter molds to a thickness approximately the same as will be laid on the road, The BS 598:104 compaction procedure for the 3% percentage refusal density(PRD) test is repeated if necessary to achieve and absolute refusal density. Vibrating hammer is an alternative method to cast specimen to the refusal condition. Sample should be mixed so that they can be compacted immediately afterwards at an initial temperature of 140 ± 5°C for (80/100) penetration grade bitumen or 145± 5°C for (60/70) penetration grade bitumen.

It is suggested that trial mixes with a bitumen content which corresponds to approximately 6 percent VIM in the Marshall test, are used to

i. Determine the mass of material required to give a compacted thickness of approximately the same thickness as for the layer on the road.
ii. Determine the number of compaction cycles which will ensure that absolute refusal density is achieved.

After these tests have been completed, samples are made with bitumen contents starting at the Marshall optimum and decreasing in 0.5 percent steps until the bitumen content at which 3 percent voids is retained at absolute refusal density can be determined.

A minimum of three trial lengths should be constructed with bitumen contents at the laboratory optimum for refusal density (93 percent VIM) and at 0.5 percent above and 0.5 percent below the optimum. These trials should be used to:

i. Determine the rolling pattern required to obtain a satisfactory density
ii. Establish that the mix has satisfactory workability to allow a minimum of 93 percent of PRD standard compaction (BS 598:104) to be achieved after rolling.
iii. Obtain cores so that the optimum binder content which allows at least 3 percent VIM to be retained at refusal density can be confirmed.

For a given aggregate and grading, cores cut from

the compacted layer can be expected to give a constant value of voids in the mineral aggregate (VMA) at the refusal density, irrespective of bitumen content. This will allow a suitable binder content to be chosen to be given a minimum of 3 percent VIM at refusal density.

A minimum of 93 percent and a mean value of 95 percent of the standard PRD is recommended as the specification for density on completion of compaction of the layer. From these trials and the results of laboratory tests, it is then possible to establish a job mix formula. This initial procedure is time consuming, but is justified by the long term savings in extended pavement service life that can be obtained. After this initial work, subsequent compliance testing based on analysis of mix composition and refusal density should be quick, especially if field compaction can be monitored with a nuclear density gauges any other approved mean.

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RURAL ROADS – PAVEMENT APPLICATIONS SIMPLIFIED

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Abstract

Roads that belong to the rural regimes are characterized by having low volume of traffic mostly with a single to intermediate lane capacity and catering to remote & far off locations of habitats, places of interest, farms etc across the island. They carry low volume compared to National Roads. Most of C & D class Roads, Pradeshiya sabha Roads and a few B class Roads too may come under low volume Roads. Rehabilitating or improvements to these roads requires resurfacing & making corrections for edges. However since this category/ sector of roads exhibit a similarity a common simplified methodology of pavement design (overlaying) with typical sections can be adopted. The significance is that the engineer is able to make quicker and easy decisions and minimize time, cost & resources spent on detail pavement investigations, lab testing & designing.

This paper considers the possibility of adopting simplified typical sections for rural roads that will comprise of flexible & rigid pavement types incorporating standard bases and subbases, concrete surfacing, block paving, or asphalt surfacing.

The proposed different options of pavement overlaying that may be applied as a typical section for a particular range of ADT and subgrade CBR have been included with the experience gained as best practices. A common Structural Number (SN) for the existing pavement of rural roads was derived based on this study of 28 number of roads with 161 sections having test pit data of existing pavement belonging to Uva, Sabaragamuwa, NCP, Eastern, & North Western provinces. Traffic predictions can be analysed to determine reasonable design traffic in terms of a correlation between design CNSA vs ADT. This relationship was obtained for a limited data set for the current study of LBFP roads. The percentage of heavy vehicles (HV's) extracted from the vehicle composition for this purpose was analysed to get a representative HV's (truck traffic) percentage.

Traffic ranges are suggested for a design CNSA of applicable range less than 1.5msa with a reasonable assumption made in respect of heavy vehicles (truck traffic). Accordingly thickness design sections are given for a range of subgrade strengths given in terms of CBR.

Pavement overlaying for low volume rural roads can be made easy with the introduction of typical layer thicknesses. With reasonable visual assessment of the pavement & subgrade conditions and few testing the engineer is able to make easy decisions for viable layer thicknesses knowing the average daily traffic plying the road.

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