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RESEARCH ARTICLE

Review of asphalt binder grading systems for hot mix asphalt pavements in Sri Lanka

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Abstract: There are three main asphalt binder classification systems; penetration, viscosity and Superpave. The penetration grade 60 –70 binder is used for road constructions in Sri Lanka. The objective of this study was to review the existing asphalt binder grading systems and find the most suitable grading system for Sri Lanka. Performance of the road sections constructed with different penetration grade binders were examined and it revealed that the binder grade significantly affects the performance.

A survey was conducted among the professionals involved in the road construction industry to evaluate the current practices. Laboratory test results of the University of Moratuwa and test reports collected from road contractors and the Research and Development (R&D) Division of the Road Development Authority (RDA) were investigated. The test results revealed that binders used in the industry are highly temperature susceptible, though the binder has complied with the standards.

Data collected from the Meteorological Department for the last 20 year period were analyzed to estimate the maximum and minimum pavement temperatures, which are required for Superpave binder grading. An algorithm validated for Sri Lankan conditions was used to estimate the pavement temperature from ambient temperature. The requirement of different binder grades for different zones has been identified and a GIS map was developed to select the suitable binder grades for specific road sections in Sri Lanka. PG 58-16 can be recommended for majority of roads while PG 52-10 can be recommended for the regions in the central hilly area of the country where low temperature prevails. Similarly, AC 30 and AC 20 can be specified for high and low temperature zones, respectively.

Keywords: Asphalt, binder grading, penetration, Superpave, viscosity.

INTRODUCTION

The durability and the long-term satisfactory performance of pavements (road carriageways) are influenced and affected to a great extent by the pavement ingredients (materials) and their inherent properties. It is very pertinent to consider properties of the bituminous binders and the bitumen content as a quality control measure in a bituminous construction. The construction sector should be interested in using the right type of bitumen for obtaining durable pavements (Nagabhushana, 2009).

Penetration grading system is the first standard method adopted by the American Society for Testing and Materials (ASTM) Committee D04 on road and paving materials in 1918. The viscosity grading system was introduced in 1960. Both methods are empirical methods, based on past experiences and observations. The latest grading system, the Superpave grading system, was introduced in 1998. Superpave grading system was developed as part of the Superpave research effort to introduce more accurate and fully characterized asphalt binders for use in hot mix asphalt (HMA) pavements. It was based on the idea that asphalt binder properties should be related to the conditions under which it is used. For asphalt binders, this involves expected climatic conditions and ageing considerations (Adedimila & Olutaiwo, 2003).

The penetration grading system is currently used in Sri Lanka while many of the developed countries have adopted to the latest Superpave grading system. Many researches are being conducted on Suprepave technology. India has developed a grading system based on viscosity. Hence, reviewing of asphalt binder grading

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systems and identifying the improvements necessary for the existing limitations and the restrains in the country are important.

The overall objective of this study was, to review the asphalt binder grading systems in line with Sri Lankan environmental conditions. The following tasks were carried out to achieve the objectives of this study.

1. Evaluation of the effect of binder grade on pavement distresses
2. Analysis of asphalt binders used in the industry with the evaluation of
   - temperature susceptibility (experimentally and theoretically)
   - the properties
   - mixing and laying temperatures
   - current industry practices
3. Selection of suitable asphalt binder grades for roads in different climatic zones of Sri Lanka and develop GIS maps

LITERATURE REVIEW

Binder testing studies go back to 1888, when H.C. Bowen invented the Bowen penetration machine (Welborn & Halstead, 1974). After several modifications, the penetration equipment became the standard for establishing the consistency of asphalt at 25 °C by 1910. In 1918 the Bureau of Public Road, USA and ASTM introduced the penetration grading system. By 1931 the American Association of State Highway and Transportation Officials (AASHTO) published the standard specification for grade asphalt on penetration. The next major change in asphalt grading specification came with the introduction of the viscosity grading system in early 1960s. Both ASTM and AASHTO adopted the viscosity grading system and provided grading specifications by measuring the viscosity at 60 °C.

Table 1: Penetration and viscosity grading system

Penetration grading		Viscosity grading	
Grade	Penetration in 0.1 mm	Grade	Viscosity at 60 °C, Poise
Pen 40/50	40 − 50	AC − 40	4000 ± 800
Pen 60/70	60 − 70	AC − 30	3000 ± 600
Pen 85/100	85 − 100	AC − 20	2000 ± 400
Pen 120/150	120 − 150	AC − 10	1000 ± 200
Pen 200/300	200 − 300	AC − 5	500 ± 100
		AC − 2.5	250 ± 50

ASTM D946 specified five binder grades based upon penetration at 25 °C. The greater the penetration, the softer the binder. In the case of viscosity grading, viscosity at 60 °C (close to maximum pavement temperature) is specified. The specifications also require a minimum viscosity to be measured at 135 °C to reduce the potential of the tender mix at the time of compaction. ASTM D3381 specifies six binder grades based on the viscosity measured at 60 °C. Table 1 provides the standard penetration and viscosity grades.

Generally, softer binder grades are used in the cold climates to resist cracking potential and harder binders are used for warmer climates to resist rutting potential.

The viscosity grading system based on a fundamental property is considered as a step forward in specifying the binder as compared to penetration grading. It requires the binder to be tested at 60 °C and 135 °C, which correspond to the typical maximum pavement temperature and the temperature at the time of mix production and placement in the field, respectively. Viscosity specification at 60 °C helps in minimizing the rutting potential, whereas, viscosity at 135 °C helps to minimize the potential for tender mixes during the paving operation. Inspite of all these added benefits, it fails to characterize the binder at low temperatures to minimize the potential of thermal cracking and pavement performance prediction.

The Superpave system is unique in that asphalt binder is specified on the basis of the maximum and minimum pavement temperatures in which the binder is expected to serve. The requirements of the mechanical properties remain the same, while the temperature at which the asphalt binders achieve the physical properties corresponds to the minimum and maximum temperatures of the pavement. For example, high temperature requires the binder to have $G^*/\sin \delta$ to be at least 1.0 kPa for unaged condition (G^* is the shear modulus in kPa and δ is the phase angle). The value of 1.0 kPa remains constant but the temperature at which this value has to be achieved depends upon the maximum pavement temperature. Another important feature of Superpave is that mechanical properties are measured on the asphalt binders of three conditions: unaged, short-term aged and long-term aged. The short and long-term ageing is simulated in the laboratory using the rolling thin film oven (RTFO) and pressure ageing vessel (PAV), respectively. The required mechanical properties under the three ageing conditions, both for high and low temperatures are specified in the Superpave specifications.

Table 2 presents the typical binder grades as specified in the Superpave specifications. High temperature of

Table 2: Superpave binder grades

High temperature grade, °C	Low temperature grade, °C
PG 46	34, 40, 46
PG 52	10, 16, 22, 28, 34, 40, 46
PG 58	16, 22, 28, 34, 40
PG 64	10, 16, 22, 28, 34, 40
PG 70	10, 16, 22, 28, 34, 40
PG 76	10, 16, 22, 28, 34
PG 82	10, 16, 22, 28, 34, 40

46 °C has corresponding low temperatures of - 34, - 40 and - 46 °C, resulting in PG 46-34, PG 46-40 and PG 46 - 46, respectively. The temperatures given in Table 2 correspond to the pavement temperatures and can be estimated from the air temperature data collected over the years. Superpave defines the high and low temperatures by 7-day average maximum air and l-day minimum air temperature. The 7-day average maximum temperature is defined as the average highest air temperature for a period of 7 consecutive days within a given year. The 1-day minimum temperature is defined as the lowest air temperature recorded in a given year. The data are collected over multiple years and the design high and low pavement temperature values are then estimated using the average and standard deviations of the data collected for a desired reliability level (Roberts *et al.*, 1996, Adedimila & Olutaiwo, 2003).

Pavement temperature models

Several research efforts have been made to relate the air temperature to the pavement temperature. Regression equations along with mathematical heat flow theories have been used for establishing the correlation. Among these, models for the prediction of high and low pavement temperatures based upon the air temperature data were established during the strategic highway research programme (SHRP). However, later SHRP established the long term pavement performance (LTPP) programme to support a broad range of pavement performance analysis leading to improved engineering tools to design, construct, and manage pavements. In this regard, the seasonal monitoring programme (SMP), a task of LTPP evaluated the effects of temperature variations on performance and validated the available models (Mohseni, 1998; Diefenderfer *et al.*, 2002). This resulted in a new set of pavement temperature prediction models for the high and low temperature grades. Given below are the models developed under the SHRP and LTPP programme for high and low pavement temperature predictions.

$$T_{pav,h} = T_{air} - 0.00618\ Lat^2 + 0.2289\ Lat + (42.4)(0.9545) - 17.78 + z.\sigma_{air} \quad ...(1)$$

$$T_{pav,h} = 54.32 + 0.78\ T_{air} - 0.0025\ Lat^2 - 15.14\ log_{10}(d + 25) + z\,(9 + 0.61\sigma^2_{air})^{1/2} \quad ...(2)$$

$T_{pav,h}$ = High AC pavement temperature at 20 mm from surface, °C
$T_{pav,h,d}$ = High AC pavement temperature at depth d from surface, °C
T_{air} = High 7-day mean air temperature, °C
Lat = Latitude of the section, degrees
d = Pavement depth, mm
σ_{air} = Standard deviation of the 7-day maximum air temperature, °C
Z = Standard normal dist. table, z = 2.055 for 98 % reliability, and z = 0.0 for 50 % reliability

The SHRP high temperature model was developed from the results of theoretical heat transfer modelling (Huber, 1994). Based upon the data collected from several sites throughout the U.S., a regression model was then developed for prediction of high pavement temperature as a function of depth. Superpave defines the high pavement design temperature at a depth of 20 mm below the pavement surface. Equation 1 represents the model developed under the SHRP programme, whereas equation 2 is the LTPP model.

SHRP low temperature models considers the low air temperature as the design low pavement temperature (Huber, 1994). The low pavement design temperature at the pavement surface is the same as the 1-day minimum temperature, since the air temperature is the same as the pavement surface temperature. This can be mathematically represented by the following relationship.

$$T_{pav,l} = T_{air} - 0.051xd + 0.000063x\,d^2 - z.\sigma_{air} \quad ...(3)$$

The LTPP low pavement temperature at the surface is presented in equation 4 below.

$$T_{pav,l} = -1.56 + 0.72T_{air} - 0.004Lat^2 + 6.26\ log_{10}(d + 25) - z\,(4.4 + 0.52\sigma^2_{air})^2 \quad ...(4)$$

Where $T_{pav,l}$ = low AC pavement temperature in °C

In the above equations (equation 1 to 4), the factor "z and air" is included to introduce the equations 5, 6 and 7 that has been successfully used by a research team at the University of Balamand, Lebanon (Khalil *et al*., 2009).

$$T_{s(Max)} = T_{air(Max)} - 0.00618 \cdot latitude^2 + 0.2289 \cdot latitude + 24.4 \quad ...(5)$$

$$T_{d(Max)} = (T_{S(Max)} + 17.8)(1 - 2.48 \times 10^{-3} d + 1.085 \times 10^{-5} d^2 - 20441 \times 10^{-8} d^3) - 17.8 \quad ...(6)$$

$$T_{S(Min)} = 0.859 T_{air(Min)} + 1.7 \quad ...(7)$$

Where;

$T_{air\ (Max)}$ = 7 – day average maximum air temperature
$T_{air\ (Min)}$ = 1 – day average minimum air temperature
$T_{S\ (Max)}$ = Maximum surface temperature
$T_{d\ (Max)}$ = Maximum temperature at a depth of d (d is 20 mm for the Superpave binder selection)
$T_{S\ (Min)}$ = Minimum surface temperature
(Khalil *et al*., 2009)

METHODOLOGY

Questionnaire survey

The questionnaire was mainly focused on obtaining industry practices on asphalt binders grading systems, binder testing and mixing and laying temperatures. The survey was conducted among those who are involved in the highway industry such as project managers, material engineers, site engineers and laboratory managers.

Distress survey

A case study on the Rathnapura - Bandarawela road was carried out to identify the binder related distresses since two types of binder have been used in the road construction. Four locations under different climatic conditions (Figure 1 and Table 3) were studied and all the pavement distresses were noted with their severity. Pavement performances were evaluated by comparing the observations of the distresses with the binder grade used.

Asphalt binder properties

Temperature susceptibility

Asphalt binder is a thermoplastic material and its consistency changes with the temperature. Temperature susceptibility is the rate at which the consistency of an asphalt binder changes with temperature and is a very important parameter of asphalt cement (Khalil *et al.*, 2009).

- *Experimental*: Penetration test was conducted at different temperatures to check the temperature susceptibility of the binder samples and the penetration *vs*. temperature graph was drawn.
- *Theoretical*: The penetration index can be used to estimate the temperature susceptibility. Penetration index of each sample was calculated using penetration and softening point data available in the test reports and compared with the allowable ranges (Roberts *et al.*, 1996).

Test report analysis

Bitumen test reports were collected from the R&D section of the Road Development Authority, Maga Neguma emulsion plant and contractors. The softening point and penetration values of test reports were compared with the allowable ranges for the respective bitumen type (Roberts *et al.*, 1996).

Data on mixing temperature of asphalt cement at plant, and laying temperature at site were collected from contractors in the road sector. The mixing and compaction temperatures were analysed.

Selection of binder grades

Based on the literature, suitable binder grades were selected for different areas where meteorological data were available using all three grading systems. Air temperature values collected from the Meteorological Department were used for the analysis. Since Superpave grading system is based on pavement temperature, the Superpave prediction algorithms were used to convert the air temperatures into pavement temperatures (Asphalt Institute, 2003). The Superpave prediction algorithms were verified with the Sri Lankan climatic conditions. Figures 2 and 3 show the thermocouple locations of the two selected roads and installations of thermocouples for validation of algorithms.

Table 3: Survey locations

Location	Name	Binder type	Distress	
			Type	Severity
1	Pelmadulla	80/100	Bleeding	High
			Shoving	High
2	Allepola	80/100	Bleeding	High
3	Oluganthota	60//70	Pavement edge failures	Low
4	Haputhale	60/70	No significant distress	-

Figure 1: Location map

Figure 2: Experiment in local roads

DATA ANALYSIS AND RESULTS

Pavement performance analysis

Figures 4(a) – 4(d) show the critical distresses identified in the survey. Summary of the observed pavement distresses and the binder grade used in these locations are shown in Table 4. Softer bitumen, 80/100 and harder bitumen, 60/70 have been used for road sections in the hot climatic zone and the cold climatic zone, respectively.

Figure 3: Thermocouple installed in the pavement

(a) Bleeding at location 1

(b) Shoving and rutting at location 1

(c) Bleeding at location 2

(d) Edge cracks at location 3

Figure 4: Pavement distresses

Table 4: Inventory data of selected locations

Location	Name of the place	Distance from Rathnapura (km)	Mean sea level (m)	Temperature °C		
				Min	Max	Avg
1	Pelmadulla	19	122	24	35	27
2	Allepola - Balangoda	41	600	24	35	27
3	Oluganthota - Balangoda	50	530	24	35	27
4	Haputhale	89	1431	13	25	21

Min - Minimum ; Max - Maximum ; Avg - Average

Surface distresses; bleeding, shoving and rutting have been observed in sections with soft bitumen. Surface distresses in those sections were a result of the use of softer bitumen in hot climatic zones. Isolated edge cracks are load related cracks induced near the joint of old and new pavement of road widening sections. This analysis clearly shows that the bitumen stiffness affects surface distresses significantly.

Analysis of binder properties

Temperature susceptibility (experimental approach)

Penetration values measured at different temperatures in the laboratory for the 80/100 and 60/70 binders are shown in Figure 5. It clearly shows that the binders used in the industry are highly temperature susceptible. The samples, which have lower penetration values at 25 °C show higher penetration values at slightly higher temperatures. Generally, a selected bitumen is checked for penetration at 25 °C in the penetration grading system and the same penetration grade binder can perform differently at service temperatures. This is one of the major disadvantages of the penetration grade bitumen and it has been shown in laboratory testing.

Temperature susceptibility (theoretical approach)

Calculated penetration index (PI) values for the 34 test reports collected from the contractors are shown in Figure 6. The penetration index should be in the range of +1 to -1 for binders used for road constructions (Roberts *et al.*, 1996). According to the penetration index computed from test reports, 50 % of samples are out of the range, i.e. temperature susceptible.

Test report data analysis

Penetration Variation

The penetration values of 24 test reports of 60/70 grade and 27 test reports of 80/100 grade were used for the analysis. Figure 7 shows the penetration values of 60/70 and 80/100 binders with their allowable ranges. In the 60/70 grade, 29 % of the samples are out of the range and 33 % of the samples are at or near the boundary. In the 80/100 grade, all the samples are in the specified range, but shows a high variation of the test results.

Softening point variation

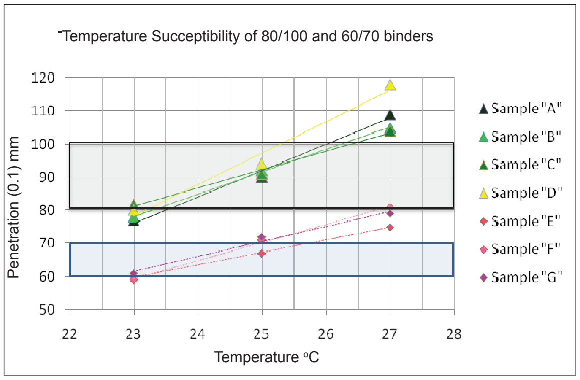
Softening point in 18 test reports from 60/70 grade and 17 test reports in 80/100 grade were used in the analysis. In 60/70 grade, all values were at or near the lower limit and in 80/100 grade, 70 % of the samples were out of the range and the rest of the samples (30 %) were at or near the lower boundary. The softening point results of 60/70 and 80/100 grades are given in Figure 8.

Softening point and penetration

Figure 8 shows the plot of softening point and penetration of 60/70 and 80/100 binders. The figure shows that 22 % of samples from 60/70 grade and 73 % of samples from 80/100 grade are out of the allowable limit. But most of the samples of 60/70 are in the boundary of the allowable limit. The samples within the range in both cases are less than 20 %.

Mixing and laying temperatures

The mixing and laying temperatures depend on the viscosity and should be at a viscosity of 2.8 ± 0.3 and 1.7 ± 0.2 Poises, respectively (Roberts *et al.*, 1996). Since the viscosity is not measured in the present binder grading system, the mixing and laying temperatures are selected arbitarily. Figure 9 shows the asphalt cement mixing and laying temperatures of 87 data records collected from different contractors. The ICTAD specification for roads and bridges specifies the minimum mixing and laying temperatures to be 150 °C and 135 °C, respectively. It was found in the survey that the contractors have not selected the appropriate mixing and compaction temperature based on the viscosity and specification limits.



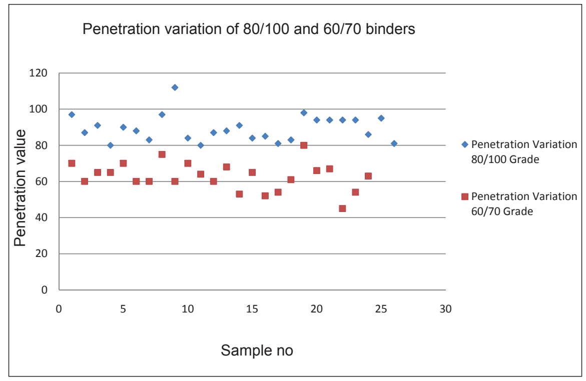
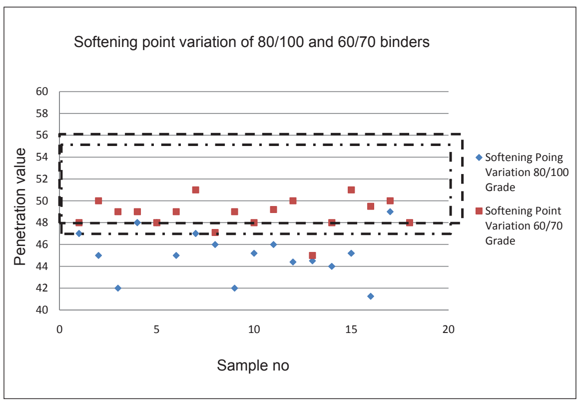


Figure 5: Temperature susceptibility of binders

Figure 6: Penetration variations of tested samples



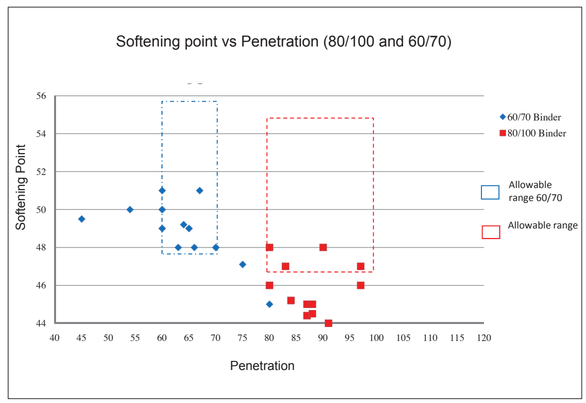


Figure 7: Softening point variation of tested samples of Asphalt

Figure 8: Softening point and penetration variation of 60/70 and 80 – 100

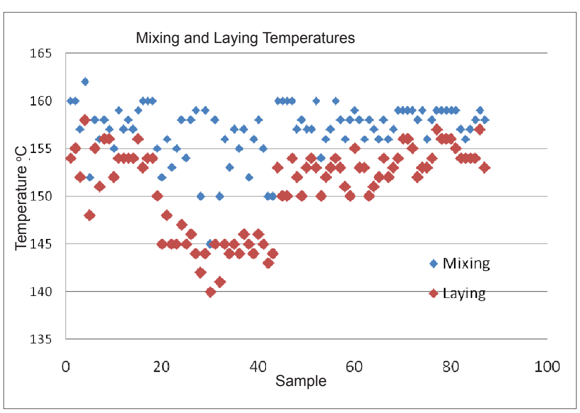


Figure 9: Mixing and laying temperatures

Questionnaire results

According to the questionnaire, industry people believed that the asphalt binder grade affects pavement distresses such as stripping, raveling, bleeding, fatigue, rutting, shoving and corrugation. More than 50 % of the industry experts did not agree with the current penetration grading system, because it measures the properties of asphalt binders only at one temperature (25 °C) and does not measure the real bitumen properties at adverse service temperatures.

Generally, the frequency of the asphalt binder testing specified is one test per 100 tons and industry does not check the properties according to the specified frequency. It was found that, the bitumen manufactures also check only the penetration and the softening point of the bitumen binders and do not conduct the other tests as given in the specification. The contractors only check the penetration and softening point of the binders due to lack of laboratory facilities, cost and time. Most of the contractors check the above parameters to just meet the specification requirements, and they do not have an understanding of its effect on distresses in hot mix asphalt.

More than 50 % of the people in the industry have observed differences between the test reports of the manufacturers and the contractors. More than 70 % have experienced the deviation of the test results from the allowable limits.

Table 5: Equation verification test results

Location 1	Morning		Evening	
	Experimental	Theoretical	Experimental	Theoretical
Surface temperature	54.3 ° C	54.54 ° C	58.9 ° C	59.24 ° C
Pavement temperature (20 mm below)	50.63 ° C	50.92 ° C	55.35 ° C	55.39 ° C
Location 2	**Morning**		**Evening**	
	Experimental	Theoretical	Experimental	Theoretical
Surface temperature	54.5 ° C	54.74 ° C	59 ° C	59.34 ° C
Pavement temperature (20 mm below)	50.6 ° C	51.11 ° C	55.5 ° C	55.48 ° C

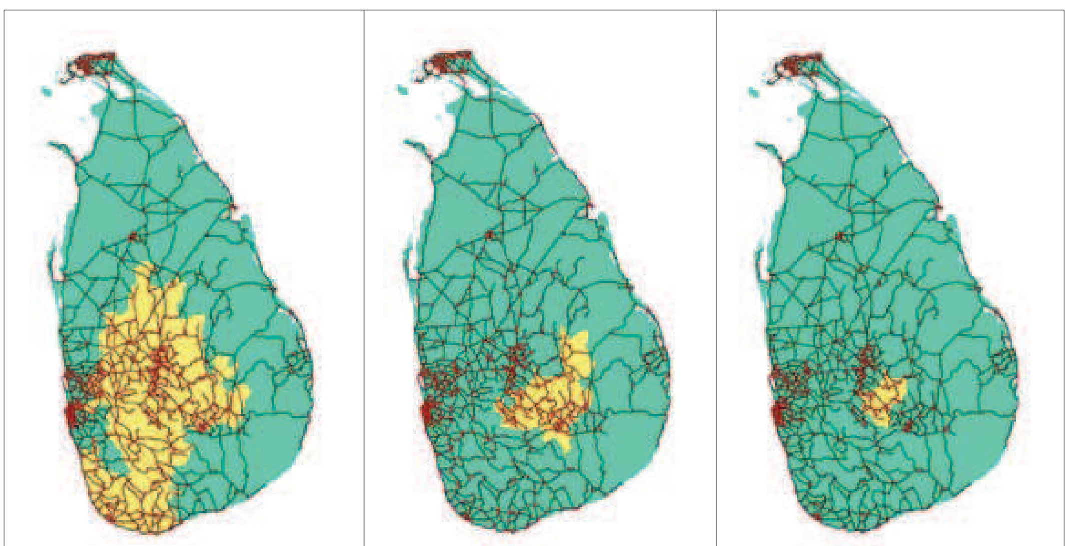

(a) Maximum temperature (b) Mean temperature (c) Minimum temperature

Figure 10: ArcGIS map based on temperature

Selection of binder grades and zoning with ArcGIS

Pavement temperature prediction algorithm used by Khalil *et al*. (2009) can be satisfactorily used for the pavement temperature estimation of Sri Lanka. Table 5 shows the verification results obtained at two locations in two road sections for two different times of the day. Thus, the validated Superpave prediction algorithms (equations 3 and 4) were used for the estimation of pavement temperature from air temperatures, which were obtained from the Meteorological Department for the last 20 years. Average 7 - day maximum and 1 - day minimum of the last 20 years in the selected locations were used to determine the Superpave binder grade for Sri Lanka. Table 4 shows the suitable binder grades for the selected locations in different climatic zones. Nuwara Eliya and Bandarawela require different binder grades, which are softer than the other binders. It is required to identify the road sections, which are in different temperature zones to select the suitable binder grades. The developed ArcGIS maps (Figure 10) show the maximum, minimum and mean temperatures of the road sections, which can be used to determine the suitable binder grades for road sections in Sri Lanka.

Figure 10a can be used for the methods where the maximum temperature is critical, i.e. Indian standards (Nagabhushana, 2009) for the penetration grading, newly adapted viscosity grading system for India (Kandhal, 2007), and prediction of Superpave grades for different crude oil blends (Ithnin, 2008). Figure 10b can be used for the methods where the mean temperature is critical, i.e. Asphalt Institute recommendations (Asphalt Institute, 1991) for the penetration grading. Figure 10c can be used for the methods where the minimum temperature is critical, i.e. Indian standards (Nagabhushana, 2009) for the viscosity grading and selection of Superpave graded binders.

CONCLUSION

The asphalt binder grading system used in Sri Lanka is the penetration grading system. It is based on empirical tests (such as penetration, softening point) and does not measure any fundamental engineering parameters of binders. The manufacturers do not provide mixing and compaction temperatures and the contractors do not conduct laboratory testing to determine them. Also, the temperature susceptibility of the binder is not checked in the present binder grading system. The viscosity grading system is more reliable than the penetration grading system, since the testing is carried out at three different temperatures; viscosity at 60 ºC and 135 ºC and penetration at 25 ºC, which relate to the properties of bitumen at high pavement temperature, mixing temperature and average pavement service temperature. In this method, the temperature susceptibility can also be checked. However, there are some disadvantages in this method as well, i.e. the principal grading does not accurately reflect low-temperature asphalt binder rheology and thin film oven test residue viscosities can vary greatly with the same viscosity grade. Therefore, even if the asphalt binders are of the same viscosity grade, they may behave differently after construction. Consistency of asphalt binders varies with temperature and neither penetration grading system nor viscosity grading system addresses this issue. Most of the asphalt binders used in Sri Lanka are temperature susceptible. It is recommended to maintain the penetration index between -1 and +1 for road asphalt to minimize the temperature susceptibility.

The Ceylon Petroleum Corporation generally manufactures only 60/70 grade asphalt binder but manufactures 80/100 on the request of users. The survey revealed that all the standard tests are conducted by the manufacturer only on the contractor's request. Otherwise, both manufacturers and the contractors test only the penetration and softening points, which are directly requested in the mix design. When the asphalt binder is harder than the allowable range, it tends to induce cracks in the pavements with the traffic load. At the lower temperature, binder becomes stiff and brittle, which induces temperature related cracks. When the binder is softer than the required level, the binder related distresses such as bleeding, rutting and shoving can be induced at hot temperatures. According to the analysis of test reports, the penetration and softening values vary widely and may contribute to the pavement distresses obsrved in A4 roads, which used two types of binders. According to the softening point data, most of the samples are at the lower end or out of the range. At high elevated temperatures, binders soften and pavement distresses such as shoving, rutting and bleeding can occur in pavements. The current practice of the Sri Lankan road construction industry is to use typical temperatures indicated in specifications (broad range) for mixing and laying temperatures. It is essential to determine the mixing and laying temperatures since the binder properties can vary. However, the current grading system does not provide mixing and laying temperature of asphalt binders.

The Superpave asphalt grading systems address most of these issues and considers traffic loading in binder selection. The binder grade is determined based on the pavement temperature of an average 7 - day

Table 6: Suitable binder grades for selected locations

Location	Zone	Penetration	Viscosity	Superpave
Colombo		60/70	AC - 30	PG 58-16
Jaffna		60/70	AC - 30	PG 58-16
Trincomalee		60/70	AC - 30	PG 58-16
Hambantota		60/70	AC - 30	PG 58-16
Ratnapura		60/70	AC - 30	PG 58-16
Anuradhapura		60/70	AC - 30	PG 58-16
Kandy		60/70	AC - 30	PG 58-16
Bandarawela		80/100	AC - 20	PG 52-10
Nuwara Eliya		80/100	AC - 20	PG 52-10
Galle		60/70	AC - 30	PG 58-16
Puttalam		60/70	AC - 30	PG 58-16
Kurunegala		60/70	AC - 30	PG 58-16
Badulla		60/70	AC - 30	PG 58-16

maximum and 1 - day minimum temperature of 20 years of temperature data. The Superpave algorithm to convert air temperature to pavement temperature was validated using measured air and pavement temperatures and it was found that equations 3 and 4 can be successfully used for the purpose. The Superpave asphalt grading system can be considered as the most acceptable grading system and PG 58-16 and PG 52-10 can be introduced for hot and cold regions of Sri Lanka, respectively.

The complexity of testing, lack of instruments and knowledge, and high cost are some of the restraints to adopt a completely new grading system. It is recommended that the viscosity grading system is more reliable than the penetration grading system. Since the testing procedure is more or less similar to the penetration grading system, it can be introduced to the country very easily. The authors have identified the bitumen grade required for Sri Lanka. AC 30 and AC 20 can be introduced for hot climatic zones and the cold climatic zones, respectively. Arc GIS maps can be used to identify the road sections in the climatic zones. Table 6 shows the selected binder grades for some selected locations.

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