FIELD EVALUATION OF THIN ASPHALT APPLICATION IN LOW VOLUME ROADS IN SRI LANKA

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Thesis submitted in partial fulfillment of the requirements for the Master of Science in Civil Engineering

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ABSTRACT

Field evaluation of thin asphalt application in rural roads

Thin Asphalt surfacing (TAS) is an innovative idea that has the potential to lower construction and maintenance costs of road construction in Sri Lanka. Laboratory based studies conducted in Sri Lanka have shown that the local materials can be used to produce TAS, and this study focuses on the usability of TAS in the field. Few concerns were found when applying this new technology in the field was taken into consideration before field trial. Such as: (1) The possibility that variations in the gradation of aggregates within the specification limit could negatively affect the characteristics of asphalt mix. Investigations were conducted to look at the impact of coarser and finer gradations on Marshall Properties: these grades represent the upper and lower limits of the proposed specification range, where both mixtures fulfilled the requirements. (2) The impact of the top level of longitudinal profile tolerance on the actual thickness of the asphalt mat. Increase in the proposed layer thickness from 25 mm to 30 mm, and adding additional surface top level correction of the base layer to meet the top level of longitudinal profile tolerance of ±10 mm are the options that have been suggested to meet the specified thickness conditions for TAS, where it was found that both approaches can be advantageous. (3) The rate at which heat is released by an asphalt layer that is thinner than traditional asphalt layer. The results of the laboratory-based testing show that paving around 8 a.m. leaves the least amount of time for compaction. This occurred because the temperature of the ground and the surrounding air was low . Findings on the time for compaction in the morning and evening are quite comparable. This similarity shows that base temperature is more significantly impacted by solar flux than the mix temperature. After the conclusion of surveys and laboratory experiments, it was decided to trial TAS in a road in the Gampaha district with low volume traffic. Construction was done in two sections. Section 1 was constructed with a 30 mm thickness and Section 2 with a 25 mm thickness. Under the test section's field conditions, the results for 30 mm layer thickness were significantly better. The temperature reduction of the asphalt layer surface over time was observed during the trial and the time available for compaction was less than 20 minutes. Through this study it was verified that TAS mixtures within the proposed aggregate gradation limit, satisfy specification requirement, top level surface tolerance of the base layer should be adjusted to ±10 mm, it is advantageous to have 30 mm thick TAS layer rather than 25 mm TAS layer considering the fluctuations of surface level of base layer and sunny noon time is more favourable to lay TAS considering the time available for compaction. It was identified that 30 mm thick TAS sections is more attainable than 25 mm thick TAS section during field applications.

Key words: Thin Asphalt surfacing, low volume road, gradation variation, topographical survey, heat reduction rate

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LIST OF ABBREVIATIONS

TAS - Thin asphalt surfacing

LVR - Low Volume Road

CNESA - Cumulative Number of Standard Axle

HMA - Hot Mix Asphalt

NMSA – Nominal Maximum Size of Aggregates

ICTAD - Institute for Training and Development

SSCM - Standard specifications for construction and maintenance

TA – Traditional Asphalt

VMA - Voids in Mineral Aggregates

VIM - Air Voids in Total Mix

DGAB – Dense graded aggregate base

1 INTRODUCTION

1.1 Background

The cost of maintaining roads continues to escalate even at a time when roadway funds are declining. In order that the highway system to be kept in a good state, methods for lowering the cost of road development and preservation are required. Numerous innovative ideas, such as Thin Asphalt surfacing (TAS), Carbon Black Modified Asphalt, Warm mix Asphalt, Semi-rigid pavement, have the potential to lower these construction and maintenance costs. When properly implemented, these approaches will enable lower cost per ton of asphalt mix and, in some situations, enable the construction of thinner overlays, leading to a reduction in quantities and overall prices without decreasing performance. High volume highways that carry the majority of daily traffic have been the focus of the majority of asphalt pavement research. While high volume roads carry the majority of traffic, low volume routes make up a larger portion of the roads in Sri Lanka [1].

In Sri Lanka, there are over 150,000 km of roads, and 75% of those are considered to be low volume roadways with annual average daily traffic of 1000 vehicles per day or less [1]. These roads are essential for the growth of rural communities and the transportation of people, goods, and services. By delivering agricultural goods to urban areas, most of these low-traffic routes would be actively advancing the economy and welfare of our country [1].

Better surfacing for these roads has become a basic requirement in recent years, and conventional asphalt pavements are not recommended because of their thick layering and correspondingly higher cost [2]. Therefore, utilizing thin asphalt concrete layers can be a viable option. Few nations, such as Australia and New Zealand, have already started using thin asphalt layers for their roadways, but Sri Lanka has not yet [3]. Therefore, it is crucial to study and make use of the thin asphalt layer's applicability in LVR in Sri Lanka.

There is already an asphalt mixture that can be used on low traffic roads that uses aggregates with NMSA of 10mm and 7mm [4]. To assess the efficiency of thin asphalt layers as a new technology in road pavement, field testing is necessary to assess the efficiency of applying in Sri Lankan roads to local conditions.

Low volume roads (LVR) are defined as those with an annual average daily traffic of less than or equal to 1000 vehicles per day. Despite this, LVR are crucial for the development of the nation because the expansion of road networks are essential for our nation's economic progress. These roads' Cumulative Number of Standard Axle (CNESA) values are notably low, therefore the 50 mm asphalt layer with 20 mm aggregates used in the pavement designs are too conservative [4]. Numerous studies indicate that a wearing course of 25mm to 30mm would be adequate to carry light traffic. Furthermore, it should be highlighted that TAS can be used to reduce the energy, material, and financial costs associated with Hot Mix Asphalt (HMA) [4].

In Sri Lanka, the majority of LVRs have a gravel surface. There are many road projects being carried out to pave roads with asphalt and concrete. However, a 50mm minimum asphalt layer thickness is still in place as per the empirical code "Overseas Road Note 31" (ORN-31) that was created many years ago [5]. Although more expensive and requiring more materials, traditional asphalt is regarded as being durable. Additionally, there are less resources accessible due to a number of factors, thus it will be important to identify new sources of material to meet demand for upcoming road construction. Therefore, it is crucial to develop effective methods for constructing road projects.

Laboratory studies conducted in Sri Lanka have shown that the local materials can be used to produce TAS, and this study focuses on the usability of TAS in the field [4]. Few concerns were identified for the field application of this new technology, which could have an impact on the TAS field testing. Case studies include the possibility that variations in gradation within the limit could negatively affect the characteristics of asphalt mix, the impact of the top level longitudinal profile tolerance of base layer on the actual thickness of the asphalt mat, and the heat reduction rate of asphalt layer that is thinner than the tradition road construction practices.

Tolerances are constructive deviations permitted for the pavement's layer thicknesses from the thickness specified during the design phase. Although it may be assumed that there would be no variances between layer thicknesses as designed and as constructed, actual practice shows that there are variations due to excess or imperfection as a result of incorrect construction techniques or insufficient quality control. The contractor is able to complete the pavement construction within the permitted variation limits due to the tolerances contained in standard clauses like 'ICTAD SSCM'. The current tolerance limit for the base layer top level of the longitudinal profile, however, may have a negative impact on the use of TAS in the field, when laid thicknesses in various regions exceed the limit. For this study, a 25 mm TAS (DG10) thickness is proposed. The New Zealand Standard stipulates a tolerance for layer thickness of TAS of 5 mm. Additionally, the New Zealand requirement specifies that any TAS must be at least 20 mm thick [6, 7]. The +15mm/-10mm tolerance limit currently used in Sri Lanka may have an impact on the layer thickness of TAS.

The most important and directly related criteria for the compaction of HMA are rolling methods, procedures, mix temperature, mix properties, soundness and stiffness of the underlying base, and the type and number of roller passes. The hot mixed asphalt's compaction is greatly influenced by that temperature. Since TAS is a newer pavement technique in Sri Lanka, it is essential to assess whether the time available for compaction is sufficient for the country's conditions and regulations. Due to the difficulty in appropriately densifying the mix before cooling as the mix temperature's quick reduction, thin layers are difficult to compact properly and achieve the desired density.

In this study, the aforementioned problems were thoroughly investigated, and then plant trials and field tests for TAS were conducted with the assistance of the Road Development Authority, Sri Lanka.

1.2 Problem Statement

It is crucial to put into practice an economically viable option for the construction of asphalt pavements since LVR development is important for the expansion of the nation's economy. The minimum thickness for asphalt pavement is 50mm for traditional asphalt pavement (TA), according to Sri Lankan specifications for road construction and maintenance. Normally, TA is regarded as durable but costs more, needs more materials, and is not required for LVR. Therefore, it's important to utilize the resources at hand effectively. An asphalt mixture that can be used on low traffic roads that uses aggregates with sizes of 10mm and 7mm has already been developed. The efficiency of thin asphalt concrete layers in low volume roads must be evaluated in the field. Before installing the trial surfacing, it is important to evaluate the factors that will have an effect on the introduction of TAS in Sri Lankan conditions, including the effect of aggregate gradation tolerance, longitudinal profile variation, current level tolerance used in Sri Lanka, and the effect of the TAS layer's rate of heat reduction. Additionally, a field trial should be implemented to see whether laying TAS in Sri Lanka is feasible and adaptable.

1.3 Objectives

- To introduce a material-efficient method of constructing low volume roads
- To assess the adaptability of thin asphalt layer on LVR projects
- To validate the Marshal mix design and aggregate blending for thin asphalt concrete through trials
- To identify the means to create optimum base layer longitudinal profile condition that can be used for thin asphalt concrete pavement
- To determine the heat reduction rate of TAS through laboratory based investigation.
- To find the optimum layer thickness for thin asphalt concrete pavement accordance with field condition
- To check the adaptability of thin asphalt concrete layer on LVR.

1.4 Research Scope

Developing a sustainable method on construction of low volume roads in Sri Lanka, by implementing sufficient minimum thickness for Hot mix Asphalt concrete pavement, in order to save material, energy and cost, and support country's developing economy.

2 LITERATUREREVIEW

Bitumen, mineral filler, fine and coarse aggregates, are the components of asphalt concrete, which is a dense graded, premixed bituminous mixture. The structural backbone of pavements is made of coarse and fine aggregate, while bitumen serves as the mixture's binder. When correctly laid out with the right ratio of components, it will result in a surface that is exceptionally durable and capable of supporting the highest traffic [8].

In Sri Lanka, low volume highways are often defined as having an average daily traffic of less than 1000 vehicles [4]. In order for rural communities to grow, these highways are crucial. Even though there is now little traffic on particular routes, with time, the pavement deteriorates. Therefore, these roads need to be carefully mended and maintained.

2.1 Thin Asphalt surface (TAS)

The Cumulative number of standard axles values are much less in roads and the pavement designs with 50mm asphalt concrete are overly conservative. TAS where the wearing course thickness lies between 25mm-30mm would be sufficient to carry to low volume traffic. Many nations, including Australia, New Zealand, the United States of America, etc., have adopted thin asphalt-surfaced pavements [4]. China developed and designated UWM10, a dense graded ultra-thin wearing course combination with a nominal maximum aggregate size of 10 mm. [9]. Australian government has developed a guild lines for thin asphalt with thickness of 20 and 25 mm with Nominal Maximum Size of Aggregate of 7 mm and 10 mm respectively and is recommended for urban roads with CNSA value less than $1*10^5$. In a study by E. Beuving’s says that, Traditional asphalt concrete and thin layer pavements both have a design life of 15 years when applied to secondary European roads [10].

2.2 Current practices in Sri Lanka

Most of Sri Lanka's low volume roads are looked after by local authorities, who frequently neglect them due to a variety of problems such financial insufficiency and lack of technical personnel or equipment.

However, there are many road projects being carried out to pave low volume roads with asphalt and concrete. Still, a 50mm minimum asphalt layer thickness is maintained. Therefore, it's important to devise effective methods for building road projects.

2.3 Previous researches in Sri Lanka related to TAS

Previous researches were carried out in university of Moratuwa based on experimental study with commonly used Bitumen in Sri Lanka and locally available aggregates for Aggregate gradation of dense graded (DG 7 & 10), from New Zealand Transport Agency's specifications. New Zealand specification was selected here because of the similarities of pavement temperature during summer in New Zealand and Sri Lanka. Marshal properties of samples made out of 60/70 bitumen which is recommended for road surfacing in Sri Lanka and locally available aggregates fulfilled the design requirements mentioned in New Zealand specification. Mechanistic pavement analysis shows the minimum paving thicknesses of the TAS pavements were held adequate structural performance under fatigue and rutting [4].

2.4 Effects of gradation of aggregates on the Marshal properties of TAS

Mineral aggregate makes up between 90 to 96% of the asphalt concrete mix's weight, or between 75 to 85% of the mixture's volume. It makes a big difference in how well something can withstand various external loads and environmental conditions [11]. Designing asphalt mixtures is a challenging procedure that calls for careful material proportioning to meet the volumetric and mechanical requirements of the combination. In order to meet project requirements, the evaluation and selection of aggregate gradations takes up the majority of the time throughout the mix design process [12]. The particle size distribution, or gradation, of the aggregates, is the most important factor affecting the overall performance of the pavement material. Because it is one of the factors that has the most influence on the Marshall Properties of an asphalt concrete mix. The best aggregate gradation is the one that results in the maximum density. When fine particles are properly packed between coarser particles, the best gradation results, minimizing the vacant space between particles [11].

Since aggregate makes up the great majority of the paving mixture, it has a substantial impact on the structure's final engineering qualities. The asphalt concrete mixture normally comprises between 35 to 65 % coarse aggregate for a nominal maximum size of 19.0 mm. A texture suited for a thicker than 50 mm high traffic volume road asphalt layer is frequently provided by this material. There are several aggregate attributes that can impact mix properties in a variety of ways. For instance, if the aggregates used during the mix design step are weak, they may disintegrate quickly when exposed to the Marshall hammer. Due to the increased particles and filler content in the mixture, a higher-than-normal Marshall stability may occur [13].

One crucial aspect of aggregates that affects the long-term deformation of hot mix asphalt is gradation. Therefore, it's important to investigate how variations in aggregate gradation within the established parameters may impact key bituminous mix design characteristics. For their structural strength, asphaltic concretes significantly rely on the mechanical interlock and friction between the aggregate particles. It is possible to develop a lubricant that makes the material workable, promotes compaction, and alters the properties of the final combination by adding a binding agent to the gradation, such as bitumen. It is important to control how much binder is added to the gradation since too much or too little might impair the mixture's properties. But it's important to realize that modifications to aggregate grading may have a similar effect. [11].

According to Arijit Kumar Banerji et al. (2014), bituminous mix's essential mix design qualities can be affected by variations in aggregate gradation that stay within certain bounds [14]. According to Afaf A.H.M. (2014) [15], coarse gradation of the asphalt mixture design yields superior results against flow, whereas fine gradation exhibits the greatest degree of deformation. In order to compare each variation, Amir Golalipour et al. divided the gradation limit into three bands: upper, medium, and lower band. From the sieve diagram, the medium gradation of each band was chosen. According to their research, the upper gradation band (finer grading) performs well against rutting. In addition to having a high stability value, the top band aggregate also displayed less permanent deformation [16].

When implementing new technologies in Sri Lanka, such as TAS, it is important to consider how they might affect the use of local materials. Therefore, by segmenting the gradation limits into separate regions and conducting research, this study examines how Marshall Properties are affected by coarser and finer gradations and focuses more closely on the influence of aggregate gradation of TAS.

2.5 Effect of Variation in Longitudinal profile of Base layer in TAS

When considering the impact of variations in the base layer's longitudinal profile in thin asphalt surface, ABC (Dense Graded Aggregate Base (DGAB)), a frequently used base layer material, is an important part of the pavement. The base layer, a crucial part of the pavement's structure, helps to reduce the stress caused by traffic loads while also offering the other layers the ideal structural support. A vital element in the current road construction process is the creation of dense graded aggregate bases [17].

The dense-graded mixture makes use of each size material's best qualities in the final result. When appropriately keyed and confined, the aggregates have significant internal friction that prevents them from shifting under heavy loads. If other mechanical forces are not created, there will be less internal friction in the material as particle sizes decrease and supports less load. Cohesion starts to play a huge role in the stability of the material as the voids are smaller and the regions of contact get bigger. Small voids and moisture-locked films stop the mixture from absorbing a lot of water, which would reduce its ability to carry loads [18].

The current practice in LVR construction of base layer consists of four parts; Mixing, Laying, Levelling using motor grader and Compaction with roller compactor. Level survey of base layer are taken prior to laying asphalt concrete as shown in Figure 2.1 and corrections are made until the level variations are within tolerance range.

Figure 2.1 Level survey prior laying asphalt layer

When constructing a road, the pavement layer's design thickness must include a tolerance. The performance of a pavement is significantly influenced by design and construction consistency. Layer thicknesses significantly affect how flexible pavements perform under load. Differences in layer thickness between as-designed and as-built circumstances have a substantial influence on the performance of a pavement structure. Granular foundation and sub-base layer thickness variations that are within construction tolerance have no discernible impact on the performance of the pavement [19].

Australian specification requires 10 mm tolerance in design base layer level and Sri Lankan ICTAD SSCM specification requires tolerance for base layer as +15/-10 and tolerance for asphalt layer thickness as ±6 [6, 7].

Variations in layer thickness imposed on by constructive issues have an impact on the durability of the pavement structure. In this regard, numerous research investigations comparing asphaltic pavement in its as-designed and as-built states reveal a sizable thickness difference between the two. These modifications show a normal distribution, and the tendency is for thin layer thicknesses to be higher than desired [20].

The layer thickness of TAS could be impacted by the tolerance limit currently used in Sri Lanka. The top level of the longitudinal profile of the base layer's tolerance may negatively affect the effective thickness of TAS on the field, because the intended design thickness of TAS is between 20–30 mm. Evaluation of base layer condition is crucial for adjusting to present practices while implementing new technologies like TAS. As a result, this study offers a survey approach to assess the applicability of TAS in current circumstances.

2.6 Effect of mat thickness in compaction of TAS

The most crucial element influencing an HMA pavement's final performance is compaction. If the asphalt mix is not compacted to the appropriate density level, even an HMA with all the acceptable mix design qualities would function badly under traffic.

The amount of time that can be used for compaction is one of the main determining elements during the laying procedure. The time it takes for the HMA to cool and stiffen to the point where it can absorb the applied compaction energy without causing the aggregate particles to shift is referred to as the "Time available for compaction" [21]. Most likely, the single aspect that has the most influence on how well HMA is compacted is the temperature present at the moment of compaction. How rapidly asphalt pavements cool depends on a number of factors, including the beginning temperature at the time of construction, the base & air temperatures, the thickness of the asphalt mix layer, and the surrounding circumstances. It is common knowledge that the length of time required for HMA compaction decreases as the cooling rate rises. Estimating the cooling rate becomes even more important due to the limited time available for mix compaction in adverse circumstances [22].

According to Tegelar and Dempsey, 10 minutes is the absolute bare minimum amount of time that can be allowed for compaction when using modern machinery. To forecast the quantity of time available for compaction under various combinations of variables, cooling curves are also being built [23]. Thin asphalt surface and performance grade asphalt are now widely used, especially in nations with tropical climates, thanks to recent advancements in asphalt technology. It was discovered that in nations with tropical climates, the thinner the mix layer, the quicker the mix cools, lowering the amount of time left for compaction [24].

In this study, we primarily focused on the impact of layer thickness. The factor that affects the rate at which asphalt mixtures cool is likely layer thickness. It is challenging to effectively condense thin layers in cooler climates. Additionally, due to the inability to fully densify the mix before it cools because of the rapid decrease in mix temperature, thin layers are challenging to compact properly to achieve the necessary density.

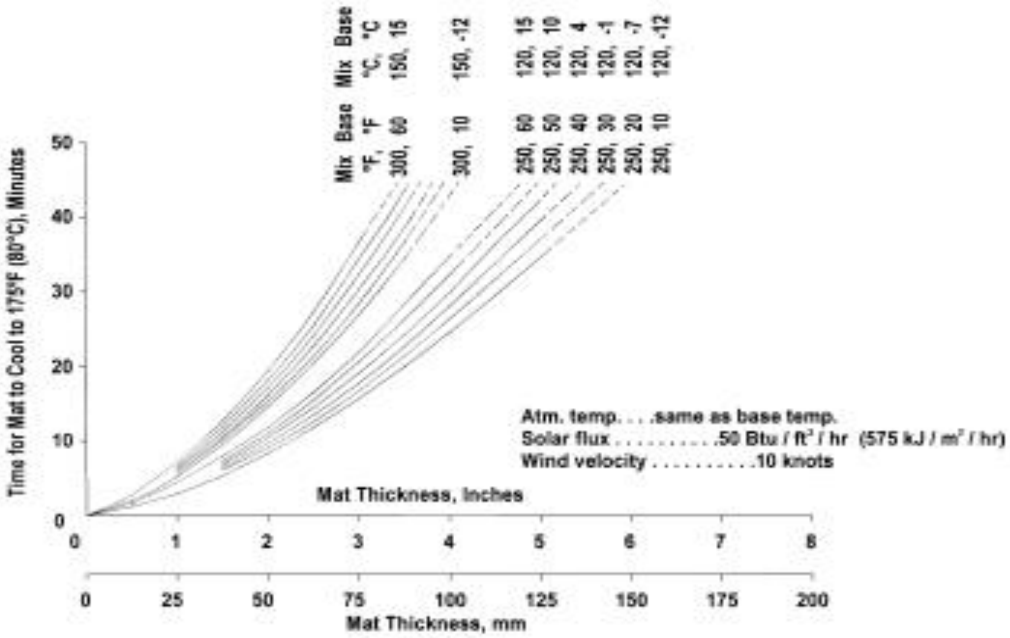

Figure 2.2 Time to layer to cool to 80 C vs layer thickness for the lines of constant mix and bases temperature - 121 C behind the paver [25]

This graph shown in Figure 2.2 is from the USA's hot mix asphalt paving manual [25]. The time allowed for compaction rises together with the layer thickness being applied. With instance, a layer with 25 mm thick will cool to the 80°C compaction cut-off temperature point in less than 4 minutes for a mix laydown temperature of 121°C and a base temperature of 15°C. It will take nearly 10 minutes for a layer 50 mm thick to cool to 80°C under the same mix and base temperature conditions. The time available for compaction increases from 4 to 10 minutes when the layer thickness is doubled from 25 to 50 mm. Under identical temperature conditions, the time to cool becomes around 29 minutes for layers that are 100 mm thick, which significantly extends the amount of time that may be used for compaction.

It is clear from these statistics that in cold weather, as it prevalent in hilly areas of Sri Lanka, there is very little time to compact a thin layer of HMA. Despite the lack of numerous publications, it is crucial to research how the compaction of TAS in Sri Lanka's environment is impacted by the thickness of the asphalt layer.

Hashim et al. (2016) used laboratory studies to examine the impact of the environment on the rate of cooling and the suitable amount of time available for compaction [26]. In order to create samples for their research, slab moulds measuring 30.5 cm by 30.5 cm by 5 cm were used. Samples were compacted using a manually operated steel-roller with an emphasis on hot mix asphalt concrete wearing and a nominal maximum aggregate size mix type of 14 mm. Their research takes into account variables such as solar flux, base and ambient temperatures (during the day and at night), and wind speed. It was discovered that environmental conditions have a considerable impact on the cooling rate of HMA, which affects the amount of time available for compaction.

The manufacturers and construction work contractors experienced a wide range of Sri Lankan environments. The mixing temperature of the mixture is typically kept at 160 ºC, while the laying temperature is typically between 140 and 150 ºC. It is crucial to confirm the adaptability of TAS in Sri Lanka by taking into account the least desirable situation of having a lower laydown temperature and a rapid heat reduction rate of a thin asphalt concrete layer. The thickness variation and base temperature differential should be examined while the other parameters are kept constant.

3 METHODOLOGY

Complete literature survey was conducted to identify the applicability of thin asphalt concrete surfaced pavement and issue and difficulties in TAS application were identified prior to filed trial.

3.1 Experimental study on gradation difference in TAS asphalt mixture

Development of different mixtures for different gradation of aggregates to determine the suitability of designed mixture for variations in field was carried out. The gradation was divided into upper and lower limits of specified gradation range and the aggregate mixture was achieved through sieving and mixing the aggregate samples. The rest of the methodology is presented in Figure 3.1. Marshall properties were examined to find out the optimum binder content and adaptability of different gradations of TAS.

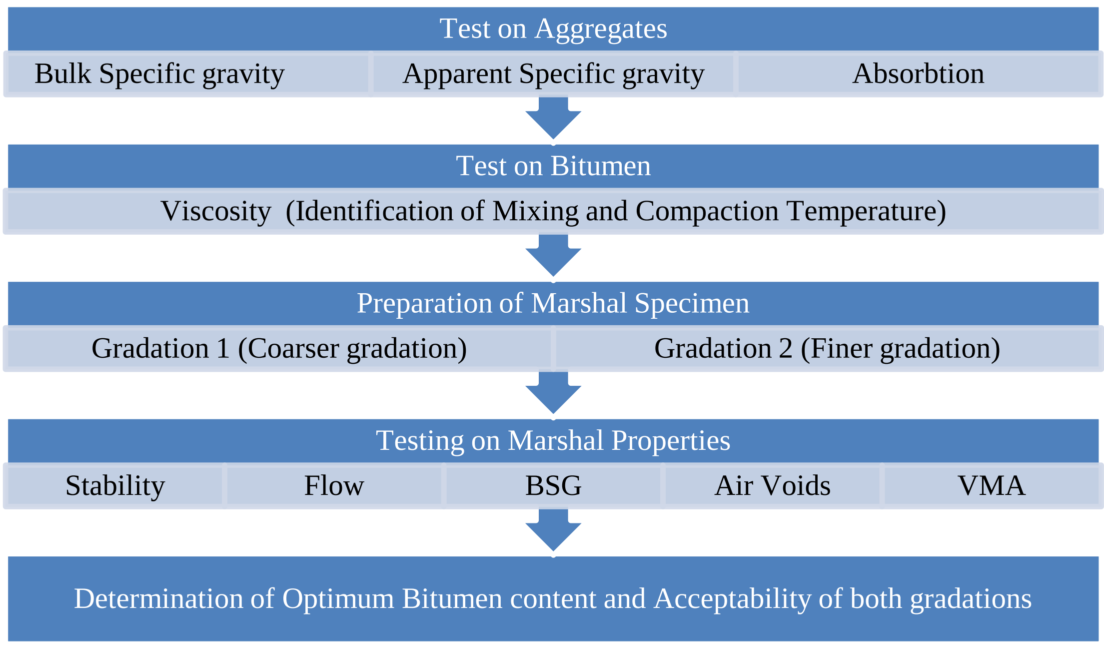

Figure 3.1 Adopted methodology for Experimental study

3.2 Effect of Variation in Longitudinal profile of Base layer

Determination of how current tolerance limit of base layer longitudinal profile affect the TAS construction was carried out. Level data collections has been done for 11 road segments in 3 different road projects. Base layer top level surface reading were then tabulated and statistically assessed by comparing means and standard deviations. These mean and standard deviation values were used to compare between different projects and with level tolerance limitations. These level data is then used to assess how it will affect the projected thickness of TAS layer. The projected TAS layer thicknesses were then used to assess the impact when increasing the proposed layer thickness from 25mm to 30 mm and when additional surface top level correction of base layer is to meet the top level of longitudinal profile tolerance of ±10 mm.

3.3 Determination of effect of layer thickness in compaction of TAS under laboratory conditions

Determination of the time available for compaction for TAS in laboratory based experiments, factoring the effect of laying under different solar flux was carried out. This experiment also utilized the asphalt mixture made up of the bitumen and aggregates mentioned in section 3.1. The asphalt mixture was made using an asphalt mixer and heated to 140 ^{o}C.

In a slab mold that was 25 cm wide, 25 cm long, and 5 cm tall, test samples were constructed. The form of an actual in-situ pavement was replicated using the slab mold. By tampering with a steel rod until the desired thickness was reached, the sample was compacted. At the thicknesses of 20 mm, 25 mm, 30 mm, and 35 mm, the necessary weight of asphalt concrete mixture for the relevant thickness was weighed in balance and placed into the molds. The temperature of the surrounding air was then measured using Mercury thermometer. Using an infrared thermometer, the temperature of the slab sample's surface and its center were monitored. Before applying the asphalt mixture, the base temperature of the surface and the ambient temperature were both monitored. To simulate both hot and cool daytime settings, samples were examined at 8 a.m., 12 p.m., and 4 p.m.

3.4 Field Trial for TAS

Application of thin asphalt concrete layer was carried on selected roads with assistance of RDA. Aggregate and bitumen samples were tested in laboratory to check whether the aggregate and bitumen properties and Marshal properties meet the standard. Blending proportions for the selected aggregates were then calculated.

Level reading were taken prior and after laying the TAS to check the thickness distribution of asphalt layer. TAS was then laid in two section; one with 25 mm thick and the other with 30 mm thick asphalt layers. Collection of core samples from the selected sections were taken and assessed. Asphalt concrete layer thickness and compaction level of the asphalt concrete layer were checked. Optimum roller pattern, suitable thickness for TAS and heat reduction rate (Time available for compaction) were assessed during this trial.

4 EXPERIMENTAL STUDY ON GRADATION DIFFERENCE IN TAS ASPHALT MIXTURE

4.1 Description

The concept of thin asphalt surfacing is relatively new to Sri Lanka, and the gradation standards for TAS differ from conventional asphalting methods. Because of this, there has been competition among manufacturers and designers to come up with the better and cheaper surfacing layer design. Therefore, this study was conducted to examine the gradation variation that frequently occurs on site. The qualities of the asphalt concrete are influenced by a number of different elements. Only the impact of the aggregate gradation variation on TAS within the defined range is the focus of this experimental study.

Additionally, this research divides the gradation limits into upper and lower gradations and conducts tests to assess the effects of aggregate gradation and the impact of coarser and finer gradation on Marshall Properties.

4.2 Objective and test plan

The purpose of this study was to ascertain how aggregate gradation and type impacted a TAS asphalt mixture's Marshall Properties (specific gravity, stability, flow, and air voids). To accomplish this, two combinations with the optimum quantity of asphalt and two distinct gradation types were compacted. These materials' volumetric and performance-related parameters were assessed utilizing a medium traffic loading with a compactive effort of 50 blows/face. To assess a range of mixtures, two blends of fine and coarse gradations bound by the New Zealand gradation standard, as indicated in Table 4.3, were used.

4.3 Assumptions and Limitations

The following are the study's assumptions and limitations:

1. A number of variables affect the Asphalt Concrete's physical characteristics. The study done here is only focused on how variations in aggregate gradation affect asphalt concrete.

2. Data was gathered from a single source as aggregates.

3. In this case, we made the assumption that while the other source aggregates' strength numerical values could change, their strength fluctuating patterns for various gradings will be the same [16].

4. Only the Marshall Test was used to determine all of the findings as Marshal method is widely practised in Sri Lanka. It may be different if other tests were carried.

4.4 Specifications

The specification used in this experimental study is from New Zealand transport agency; specification for dense graded and stone mastic asphalts [6]. The relevant parts used in this study are shown in Table 4.1, Table 4.2 & Table 4.3.

Table 4.1 Required Marshal Properties - New Zealand specification

Mix type		Compactive Effort (Blows)	Design Air void targets (%)	Stability (mm)	Flow (mm)
Traffic Category	**Application**				
Light	Wearing and Base	50	4.0	5.5	2 – 4.5
Medium	Wearing and Base	50	4.0	6.5	2 – 4.5
	High Fatigue Base	50/75	3.0	6.5	-
Heavy	Wearing and Base	75	4.0	6.5	2 – 4.5
	High Fatigue Base	50/75	3.0	6.5	-
Very Heavy	Wearing and Base		5.0	7.0	2 – 4.5

Table 4.2 Asphalt volumetric property requirements - New Zealand Specification

VMA (% Minimum)			
Mix Nominal Size (mm)	**Design Target Air Voids**		
	3.0 %	**4.0 %**	**5.0 %**
7	15	16	17
10	14	15	16
14	13	14	15
20	12	13	14
28	11	12	13

Table 4.3 Gradation ranges for dense graded asphalt concrete mixtures - New Zealand Specification

Sieve Size (mm)	Mix Designation			
	DG 7	DG 10	DG 14	DG 20
	Percentage passing sieve size (By mass)			
26.5	-	-	-	100
19.0	-	-	100	86-100
13.2	-	100	83-100	70-90
9.5	100	79-100	68-90	58-79
6.7	80-100	63-90	54-79	46-69
4.75	66-90	50-79	43-70	37-61
2.36	44-75	32-61	28-55	24-49
1.18	29-60	22-48	19-43	15-38
0.600	19-47	15-36	13-32	10-28
0.300	12-33	10-26	9-23	7-21

0.150 0.075	8-22 5-12	6-17 4-11	6-16 4-10	4-15 3-9
Minimum Layer Thickness (mm)	20	30	45	60
Binder Content (% by mass)	5.0 – 7.0	4.5 – 6.5	4.3 – 6.3	3.8 – 6.0

DG 10 is considered for this study. Aggregate gradation of Dense Graded Asphalt (Light to Medium Traffic Wearing Course Mix Types) is taken into consideration and the relevant requirements were practiced in this experimental study. As the design is for low volume roads, the light and medium traffic category was chosen. Therefore, according to Table 4.1, 50 blows to each face is applied while making Marshal sample.

4.5 Experimentations and Results

4.5.1 Bitumen

For this study, the regularly used 60–70 penetration grade bitumen as a binder material was chosen. The bitumen used for this experiment was already approved by the contractor, therefore, eliminating the necessity for testing for all the properties of bitumen. Experiments needed for the Marshal Properties assessment was carried out.

4.5.1.1 Test on Bitumen and Results

Viscosity test

The bitumen 60/70 was acquired from RDA's Research & Development division in Rathmalana, and the penetration was tested and assessed in accordance with ASTM: D 5 - 06 standards. To create a graph showing viscosity vs temperature, bitumen's viscosity was then measured at 135 °C and 160 °C.

Apparatus utilized include a rotational viscometer, a geometry measuring instrument, a spindle, a temperature-controlled thermal chamber heater, sample chambers, a temperature controller, and an electronic weighing scale.

The steps used during experiments are listed below.

1. 1. After setting the temperature controller to the desired setting (135 or 160 °C), the viscometer was heated for 5 minutes while the bitumen was heated to 110 °C.
2. 2. A sample chamber containing 10.50 g of heated bitumen 60/70 that had been heated to 110 °C was placed within a rotating viscometer as instructed by the manufacturer. Spindle 27 was used to attach the apparatus.
3. Spindle 27 was used to attach the apparatus. The complete set-up was then heated, reaching the necessary temperature in 30 minutes, and the temperature was then held for an additional 10 minutes.
4. After step 3, the spindle was adjusted to rotate at 200 RPM, and the applied torque was assessed to determine if it fell within 10% and 98% of the target range.
5. 5. Next, the instrument automatically reported the average viscosity for three minutes of integration at each temperature.
6. 6. It was able to determine the ideal mixing temperature range (280 ± 20 cSt) and the ideal compaction temperature range (170 ± 20 cSt) once the link between bitumen's viscosity and temperature was established.

Table 4.4 contains the results obtained from the viscometer, and Figure 4.1 Viscosity vs temperature graph of bitumendisplays the curve of the viscosity vs temperature obtained from the results. The graph led to the conclusions that the optimum mixing temperature range was 156.9 °C to 160.6 °C and the proper compaction temperature range was 146.7 °C to 150.4 °C.

Table 4.4 Bitumen Viscosity reading from viscometer

Viscosity (Cst)	Temperature °C
492.57	135
158.47	160

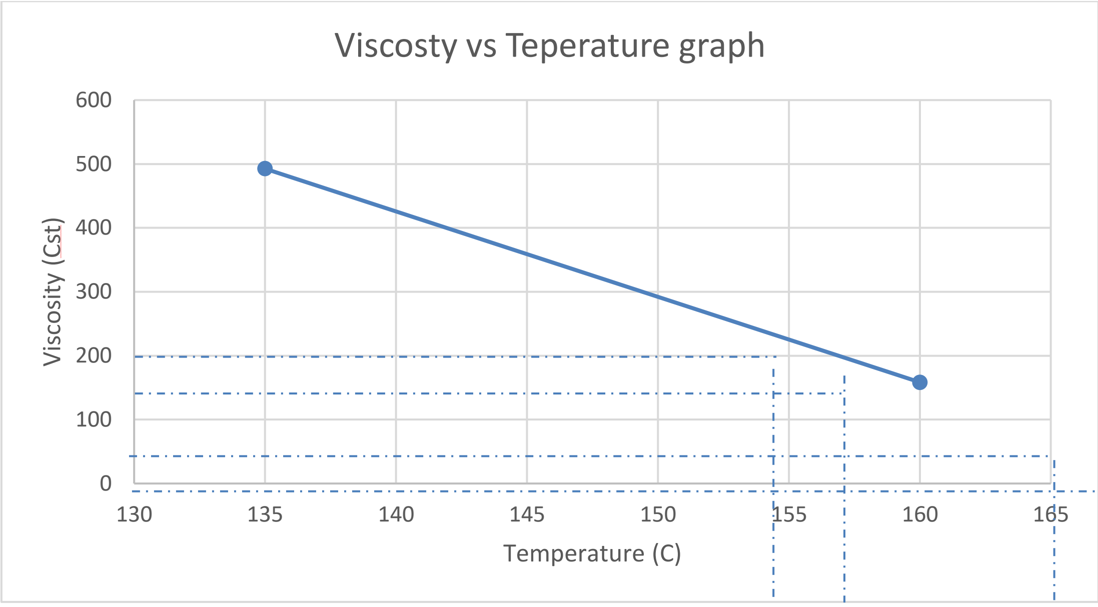

Figure 4.1 Viscosity vs temperature graph of bitumen

4.6 Aggregates and fillers

Crushed coarse aggregate, fine aggregate, and mineral filler were provided from the Road Development Authority's Research and Development Division in order to prepare the bituminous mix sample.

The plant itself examined and confirmed the physical characteristics of aggregates in accordance with Standard Specification, and it was discovered that the characteristics of aggregates are within the permitted limits. Therefore, it was not essential to test the aggregates further. Experiments needed for the Marshal Properties assessment was carried out.

Filler is described as aggregate that passes through a 0.075 mm sieve. The purpose of filler is to fill in the gaps in mixtures. Filler can make bitumen mixes stiffer and tougher by being added to the mixtures.

Table 4.5 shows the selected gradations, which are Gradation 1 with higher coarse material and gradation 2 with higher fine material which are the upper and lower limit of the specified range.

Table 4.5 Gradations of selected two cases

Size (mm)	Gradation 1	Gradation 2
13.2	100	100
9.5	79	100
6.3	68	87
4.75	50	76
2.3	32	61
1.18	22	48
0.6	15	36
0.3	10	26
0.15	6	17
0.075	4	11

Based on New Zealand specifications for road construction, aggregate gradations with a nominal size of 10mm were chosen.

The upper grade and lower grade, which were the gradation limits shown in the Table 4.3, were chosen as the two aggregate gradations for this investigation.

The boundary gradations used in the sieve diagram for the comparison of each variation. Table 4.5 displays the passing rate for each variation (fine gradation and coarse gradation bands).

4.6.1 Test of Aggregates

Some of the aggregate attributes that influence how well asphalt concrete performs are strength, toughness, durability, abrasion resistance, shape, and absorption. The computation of the Marshall characteristics required the investigation of the bulk specific gravity, apparent specific gravity, and absorption.

4.6.1.1 Tests on Aggregates

Tests on Coarse Aggregates

According to ASTM C 127 - 68, the specific gravities and absorption of DG 7 and DG 10 coarse aggregates were determined.

Apparatus used:

- A balance
- The sample container
- A watertight tank
- 4.75mm (No. 4) sieve
- Oven

The experiment's steps are listed below.

1. The aggregates in accordance with ASTM D75 was sampled and discard any components that pass a 4.75mm sieve. The aggregates were washed to get rid of any surface encrustations like dust.
2. A test sample with a minimum mass of 2 kg was selected.
3. After a thorough water wash, the aggregates were placed in an oven set at 110 °C and baked until they reached a consistent mass.
4. The samples were then allowed to cool at room temperature for two hours. After cooling for two hours, the sample was weighed (A) and immediately immersed in water for 24 hours.
5. The sample that had been submerged was then given its saturated surface dry (SSD) mass (B). Wiping the sample with a large absorbent cloth stopped evaporation.
6. The SSD sample finally immersed completely in water, and the mass was recorded (C).The important characteristics of coarse aggregates were determined using equations (4.1), (4.2) and (4.3).

$$Bulk\ Specific\ Gravity = \frac{A}{B-C} \tag{4.1}$$

$$Apparent\ Specific\ Gravity = \frac{A}{A - C}$$

(4.2)

$$Absorption = \frac{B - A}{A} * 100$$

(4.3)

Where,

A is the sample's dry mass, B is its saturated surface mass, and C is its submerged mass in water.

Followings were obtained from the laboratory based experiments

$Oven\ Dry\ Mass\ (A)$ = 2187.0 g

$Saturated\ Surface\ Dry\ (SSD) Mass\ (B)$ = 2200.0 g

$Submerged\ Mass\ (C)$ = 1404.6 g

From Equations (4.1)-(4.3) the following were calculated.

– Bulk S.G = 2.750
– App S.G = 2.795
– Water Absorption = 0.594%

Tests on Fine Aggregates

Specific gravities and absorption of DG 10 fine aggregates were computed in accordance with ASTM C 128 - 68.

Figure 4.2 pycnometer with fine aggregates

Figure 4.3 Identification of SSD condition of fine aggregates

Apparatus:

Pycnometer (Figure 4.2), an oven, a heating plate, an electronic scale for weighing things and Provisional Cone (Figure 4.3).

The procedure for the experiment is described below.

1. The aggregates were initially sieved, and those less than 4.75 mm were selected in accordance with the gradation percentage.

2. The aggregates were then heated in an oven at 110 °C until they attained a consistent mass. After allowing the aggregates to cool for two hours at room temperature, the dried mass (X) of the 1100 g aggregates was measured.
3. Since the water also contained filler, the samples were immediately submerged for 60 hours.
4. The sample was placed in a pan, kept at 150 °C, and constantly swirled to ensure even cooling.
5. The cone mold is filled with the fine aggregates in three stages during step 4, with 10 drops of given to each layer. The surface was levelled, and then the mold was raised vertically to inspect the material's SSD state. A saturated surface-dry state is when one side of the fine aggregate slumps after the mold has been removed.
6. The sample was weighed when it was determined to contain SSD (W).
7. The sample was then loaded into the pycnometer, water was injected fully without any air bubbles remaining under the top glass plate, and the sample was weighed (Y).
8. The pycnometer was then weighed after being completely filled with water and free of air bubbles (Z).

The equations (4.4), (4.5) &(4.6)were used to find the relevant properties of fine aggregates

$$Bulk\ Specific\ Gravity = \frac{X}{Z + W - Y} \tag{4.4}$$

$$Apparent\ Specific\ Gravity = \frac{X}{Z + X - Y} \tag{4.5}$$

$$Absorption = \frac{W - X}{X} * 100$$

(4.6)

W - Sample's saturated surface dry mass

X - The sample's dry mass

Y - Pycnometer mass with sample and water inside

Z - The water-filled pycnometer's mass

Followings were obtained from the laboratory based experiments

$Dry\ Mass$ (X) = 488.0 g

Mass of pycnometer filled with sample and water (Y) = 1112.7 g

Mass of pycnometer filled with water (Z) = 1404.6 g

Saturated surface dry mass of the sample (W) = 801.8 g

From Equations (4.4)- (4.6) the following were calculated.

– Bulk S.G = 2.597
– App S.G = 2.756
– Water Absorption = 2.21%
–

4.6.2 Marshall Test

The "Asphalt Materials and Mix Design Manual," which was released in 1998, served as the source of guidance for the Marshall mix design. The Annex A contain the Marshall specimens' tested qualities.

4.6.2.1 Preparation of Marshall Specimens

Figure 4.4 Preparation of Marshal samples

Figure 4.5 Prepared Marshal Sample

- The following equipment was used: an oven, a thermometer, an asphalt bench mixer, and a manual Marshall compactor. Mould assembly comprising a cylindrical mould, a base plate, and a collar extension.

The experiments' procedures are listed below.

1. 1. After being purchased, the bitumen 60/70, cylinder mold, base plate, and aggregates in the desired gradation were placed inside the oven and heated to a constant temperature of 165 °C.

2. 2. The 1200 g of selected grade aggregates that had been taken out of the oven were then put to the container containing the required amount of bitumen. The bench mixer was used to combine the sample of aggregates and bitumen. The temperature was held within a range of 156.9 °C and 160.6 °C. While the sample was being mixed using a bench mixer, the base plate, collar extension, and mold were also lightly greased.
3. The sample was completely mixed before being put into the mold assembly and then placed in the Manual Marshall compactor. As instructed in the standards (Austroads, New Zealand), the sample received 50 blows on each side (Refer Figure 4.4 & Figure 4.5).
4. The mold containing the sample was then allowed to cool for 24 hours at room temperature.
5. To prepare each sample with a variable bitumen content, the aforementioned processes 2, 3, and 4 were performed.

As there were six different bitumen contents, three Marshall samples were created for each one, yielding a total of 18 samples for each type of mixture. This experiment was carried out on both mixtures with gradation 1 and 2.

4.6.2.2 Determination of Marshall Properties

Figure 4.6 Testing of Marshal Samples

After cooling for 24 hours at room temperature, the Marshall specimens were first removed from molds using the sample extractor. Following the removal of any loose particles from the samples' surfaces using a brush, Vernier calipers were used to measure the samples' thickness and diameter.

Bulk Specific Gravity

The experiment's steps are listed below.

1. Initially, an electronic weighing scale was used to measure the dry masses of the specimens. The samples were then immersed in water for six minutes.
2. After six minutes, the samples were wiped with an absorbent cloth to remove any remaining surface moisture, and the saturated surface dry (SSD) mass was recorded.
3. The sample was totally submerged in water after step 2 and the submerged mass (SUB) was calculated.
4. The steps 2 and 3 were repeated for each specimen.

The bulk specific gravity of the combination with different binder amounts was determined using equation (4.7). The mixes with grades 1 and 2 were used in this experiment.

$$Bulk\ specific\ gravity\ of\ mixture = Dry\ Mass\ Saturated\ surface\ dry\ mass - Submerged\ mass \tag{4.7}$$

Stability and Flow

Marshall stability and flow testing device and water bath were the apparatus employed.

The test was conducted using the following procedure:

1. As a first step, the samples were held in a water bath that was kept at 60 °C for 30 minutes.
2. The sample was then taken out of the bath and placed in the Marshall stability and flow testing apparatus. The specimen was put under a constant load of 5

mm per minute until failure, at which time the stability was found to be the largest load that caused failure. When the specimen failed, the flow was computed using the dial gauge measurement (Refer Figure 4.6).

3. The test was finished 30 seconds after the specimen was taken out of the water bath.
4. During testing, steps 1 and 2 were repeated for each sample.

This experiment was carried out on both mixtures with gradation 1 and 2.

Air Voids and Voids in Mineral Aggregates

Figure 4.7 Theoretical Maximum Density test

In accordance with ASTM D2041/D2041M, the maximum theoretical specific gravity test was conducted to determine the air voids and voids in mineral aggregates.

Apparatus used:

- Vacuum bowl

- Glass thermometer.
- Mechanical agitator
- Mixing pan
- Weighing balance
- Glass cover plate
- Vacuum pump with regulator

The experiments' procedures are listed below.

1. The bitumen 60/70 and 1700 g of aggregates of the chosen gradation for DG 10 for mixtures with both gradations were heated to 160 °C in an oven as the first stage. After reaching 160 °C, the aggregates and bitumen were maintained for an additional hour.
2. Then, a bench mixer was used to combine the aggregates with a certain amount of bitumen (in this case, 6%).
3. 3. After being combined, the sample was cooled to 25 °C by being placed in an air-conditioned area. The mass of the sample was recorded after chilling it at 25 °C.
4. 4. After placing the sample into the container, water that was 25 °C was added up to 75% of the way full. The container was positioned and put together..
5. Using the vacuum pump, the 27.5 mm Hg vacuum pressure was attained in 4 minutes after the system was assembled. The trapped air was then released after 15 minutes of agitation.
6. The container was gradually detached from the setup and completely filled with water that was 25 °C. The suction was then slowly released. Care was taken not to trap air bubbles under the glass lid when the water was being poured. Then, the mass of the water and sample-filled glass container with its lid was measured.
7. The water-filled container's weight and the glass lid's weight were calculated, and enough care was taken to avoid any water bubbles becoming caught underneath the glass cover (Refer Figure 4.7).
8. 8. Both mixes had also completed stages 1 through 6. (both gradations).

The following equations (4.8) to (4.12)were used to determine the maximum theoretical specific gravity (Gmm), effective specific gravity of aggregates (Gse), air voids, bulk specific gravity of aggregates (Gba), and voids in mineral aggregates (VMA).

$$Gmm = \frac{md}{md + m - me} \tag{4.8}$$

$$Gse = \frac{100 - Pb}{100/Gmm - Pb/Gb} \tag{4.9}$$

$$Air\ voids = (1 - \frac{Gmb}{Gmm}) \times 100 \tag{4.10}$$

$$Gba = \frac{mc + mf}{\frac{mc}{Gca} + \frac{mf}{Gfa}} \tag{4.11}$$

$$MA = 100 - (\frac{Gmb \times Ps}{Gsb}) \tag{4.12}$$

Where,

md is the dry mass of the sample at 25 °C,

mt - Mass of container with glass cover and water and sample within.

m is the mass of the water-filled container plus the glass cover.

mf - Mass of fine aggregates

mc - Mass of coarse aggregates

Gse - Effective specific gravity of aggregates

Gmb - Asphalt Concrete Sample Bulk Specific Gravity

Gmm - Theoretical maximal specific gravity.

Gb - Bulk specific gravity of bitumen

Pb stands for the mass percentage of bitumen in the combination.

Ps - Percentage of the mixture's total aggregate, measured in mass.

Gba - aggregate bulk specific gravity and

Gbc - coarse aggregate bulk specific gravity

Gfa - Fine aggregate bulk specific gravity

4.7 Results and Discussion

4.7.1 Change of Stability with Bitumen Content

The minimum stability for DG10 asphalt concrete pavements according to New Zealand Specification is 6 KN at 60°C.

Table 4.1 displays the variation in stability that was found for various bitumen contents and gradings. To explore the impact of aggregate gradation on the Marshall characteristics of TAS mix, Marshall Test specimens for both gradations of aggregate were made at various bitumen contents and the results are shown in Table 4.6.

With the exception of gradation 1 at 5.5 % and 7% bitumen, the stability values for both grades are higher than the minimal value recommended in guidelines in section 4.4, highlighting the significance of the optimum bitumen content. This study shows that stability increases along with bitumen percent up to a point before decreasing again after bitumen percent is raised. As shown in Figure 4.8, the highest bitumen content for grades 1 and 2 is 6.4% and 6.5%, respectively. Gradation 1 is observed to have higher stability than gradation 2 mixture around the highest bitumen content.

Table 4.6 Stability values for both gradations

Binder content (%)	Stability (kN)	
	Gradation 1	Gradation 2

5.5	6.02	6.38
6	6.74	6.51
6.5	7.05	6.72
7	6.09	6.48

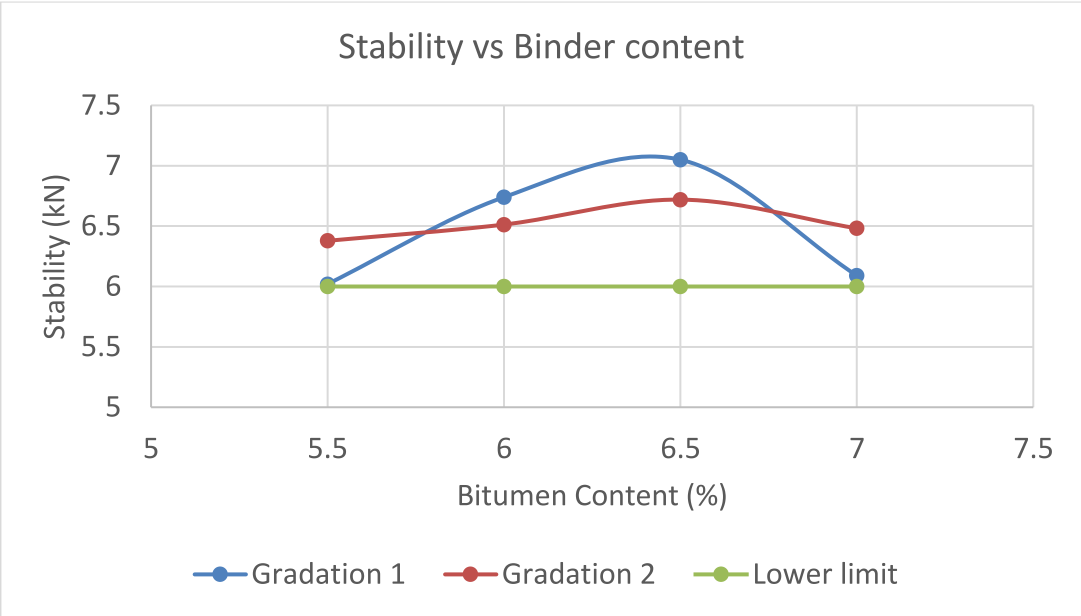

Figure 4.8 Stability vs binder content curve for both gradations

4.7.2 Change of Flow values with Bitumen Content

For TAS Asphalt Mix, New Zealand specified flow requirement is 2 to 4 mm. The flow values in this investigation fall within this range for all gradations. It has been noted that when bitumen percentage rises, so does flow value and the flow values are shown in Table 4.7. The flow values for both combinations (gradation 1&2) are substantially within the limit, as shown in Figure 4.9.

Table 4.7 Flow values of the tested samples

Binder content (%)	Flow (0.25mm)	
	Gradation 1	Gradation 2
5.5	10.0	10.7

6	10.4	11.2
6.5	12	13.3
7	13.2	15.8

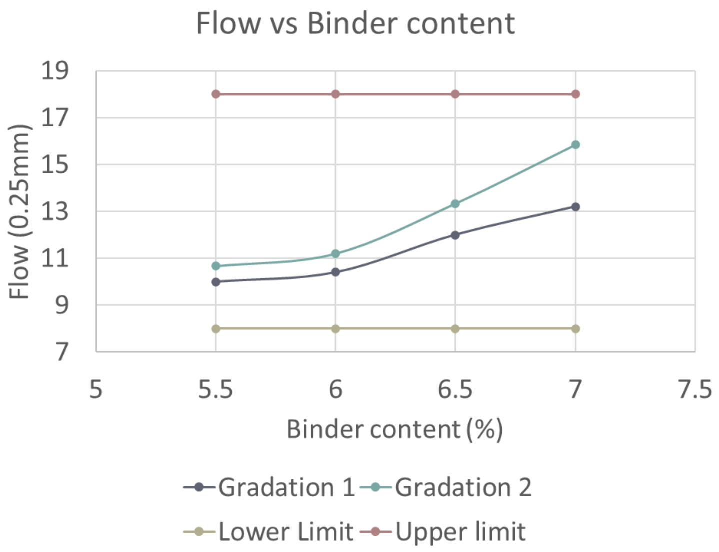

Figure 4.9 Flow vs Binder content diagram for gradation 1 & 2 mixtures

4.7.3 Change of density with Bitumen Content

As shown in the Table 4.8 and Figure 4.10, when bitumen content increases, density also rises to reach maximum point then after bitumen percent decreases sequentially. Gradation 1 has the highest density value at 6.5%, and gradation 2 has the maximum density value at 6.6% bitumen concentrations. Gradation 2 is observed to have higher bulk specific gravity than gradation 1 mixture around the highest bitumen content.

Table 4.8 Bulk specific gravity values with binder content for both gradation 1&2 mixture

Binder content (%)	Bulk specific gravity	
	Gradation 1	Gradation 2
5.5	2.386	2.378
6	2.411	2.421

6.5	2.428	2.445
7	2.418	2.427

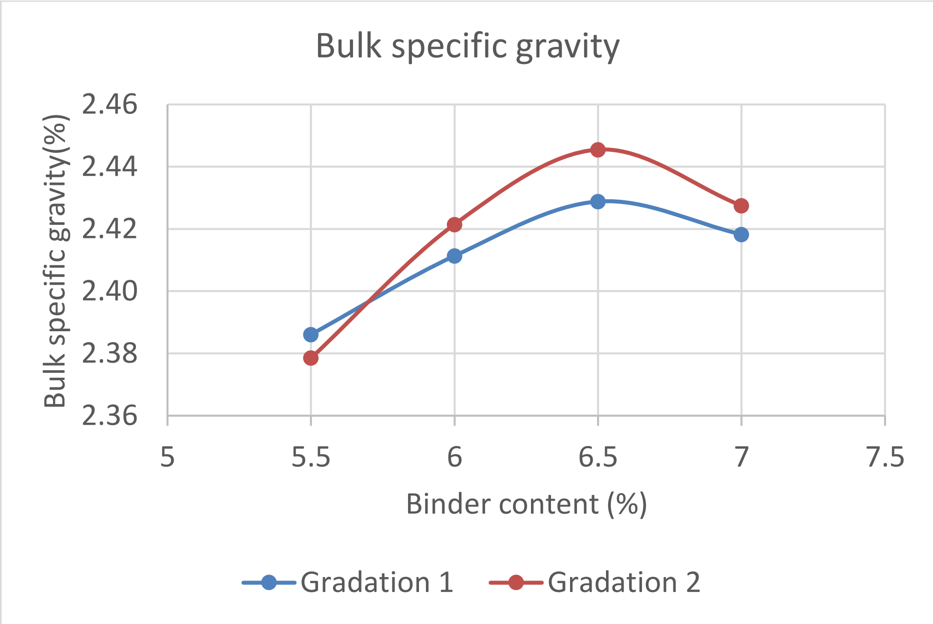

Figure 4.10 Bulk specific gravity vs bitumen content diagram for gradation 1&2 mixes

4.7.4 Change of Air Voids with Bitumen Content

The New Zealand specification specifies for air void value between 3 and 5 (Refer section 4.4). According to the Table 4.9 and Figure 4.11, the bitumen content for gradation 1 is between 6 and 7%, and for gradation 2 between 5.7 and 6.6% are within the specified range. As can be seen, gradation 1 mixtures contain more air voids than gradation 2 mixtures.

Table 4.9 Air void values for both gradation 1 & 2 mixes

Binder content (%)	**Air voids (%)**	
	Gradation 1	**Gradation 2**
5.5	6.6	6.6

6	4.9	4.2
6.5	3.5	3.1
7	3.2	2.5

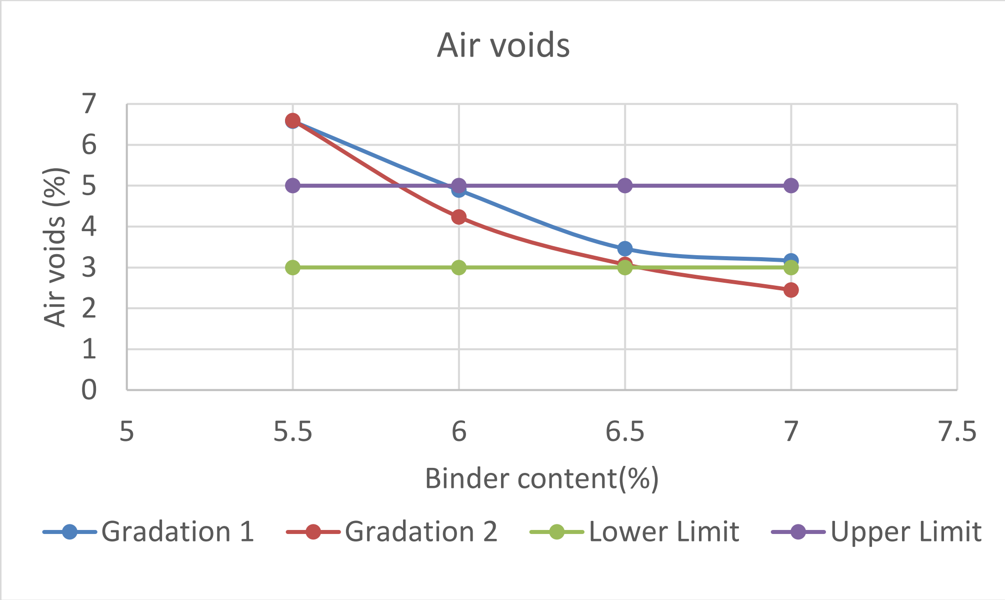

Figure 4.11 Air void vs binder content diagram for gradation 1 & 2 mixes

4.7.5 Change of Voids in Mineral Aggregates (VMA) with Bitumen Content

It was found that the value of VMA increases for all both gradations as bitumen percentage increases. The Voids in Mineral Aggregates (VMA) values for TAS mix were required to be above 15 according to New Zealand specifications (refer section 4.4). It has been noted that VMA values consistently exceed the given upper limit for both gradations.

Table 4.10 VMA values for different bitumen contents for both gradation 1 & 2

Binder content (%)	Voids in mineral Aggregates	
	Gradation 1	**Gradation 2**
5.5	15.7	16.6
6	15.2	15.7

6.5	15.1	15.1
7	15.9	16.3

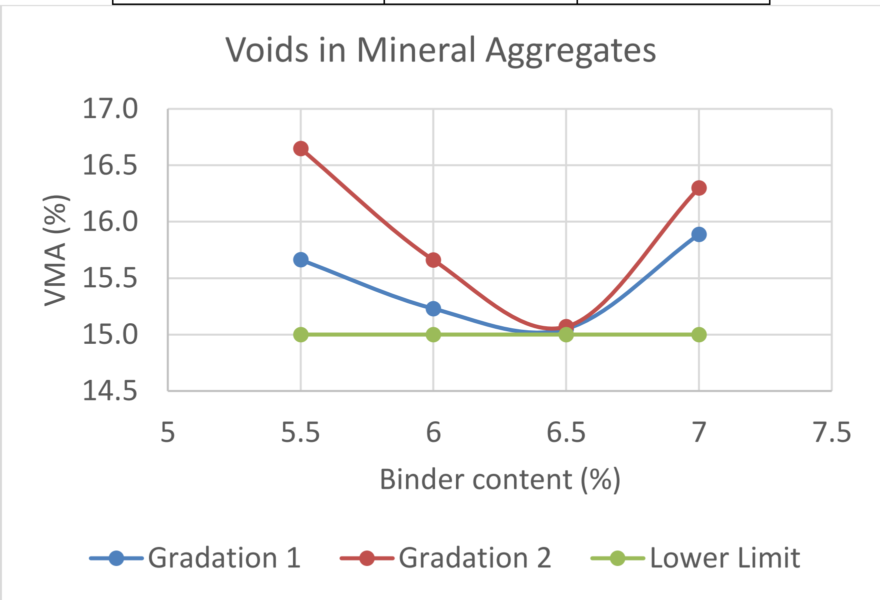

Figure 4.12 Binder content vs VMA graphs for gradation 1 & 2

4.7.6 Summary of the experimental study for determining the effect of gradation variation

The test results from the Marshal Test were investigated to ascertain the effect of aggregate type and gradation variation. According to study that considers the variation of the various mixture characteristics, the asphalt mixture with fine gradation band has the greatest flow parameter (such as stability, flow, density, air voids, and VMA.).

The Optimum Bitumen Content (OBC) and other characteristics, such as stability, bulk density, flow, and air voids, were plotted against the relevant gradations in Table 4.6 Table 4.10Table 4.9and Figure 4.8Figure 4.12. Gradation 1 indicates a rise in the ideal bitumen concentration. There is an increase in surface area as a result of the presence of finer materials. The gradation 1 of the specification's limit shows the highest stability, flow, and matching higher air void of all the mixes at OBC. A greater specific gravity is also present in the mixture with the coarse gradation band.

Optimum Bitumen Content for both gradations were found from results obtained from specific gravity, stability and air voids curve.

$$Average\ optimim\ Bitumen\ Content\ =\ (B1 + B2 + B3)/3$$

(4.13)

B1 - Bitumen percentage at the mixture's maximum specific gravity

B2 - Bitumen percentage at the mixture's maximum stability

B3 - Bitumen at design air voids as a percentage of the overall mixture

Average optimum Bitumen Content for Gradation 1 = 6.4%

Average optimum Bitumen Content for Gradation 2 = 6.37%

All the necessary requirements were satisfied while testing the upper and lower gradation mixtures at the relevant optimum bitumen content. It can be expected that TAS mixture is feasible to use in field accounting the gradation variation in Sri Lankan practices.

5 Effect of Variation in Longitudinal profile of Base layer

5.1 Description

The foundation of a flexible pavement is composed of layers that are asphaltic, granular, and stabilized. When designing such a system, consideration must be given to the features and thicknesses of each layer so that the final result can withstand traffic loads under predicted weather conditions while maintaining adequate pavement conditions.

Tolerances are permissible constructive deviances in the layer thicknesses of the pavement from the thicknesses stipulated during the design phase. Although it would be assumed that there would be no variances between layer thicknesses as designed and as built, actual practice shows that there are variations due to excess or imperfection as a result of incorrect construction techniques or insufficient quality control. Despite the fact that these individual tolerances can appear insignificant, when they are added together and applied to the entire structure, they have a considerable impact.

To guarantee that the layers created are within the permitted thickness limitations, the pavement construction process is governed by construction tolerances. The contractor is able to complete the pavement construction within the permitted variation limits due to the tolerances contained in standard clauses like ICTAD SSCM. The current tolerance limit for the base layer top level of the longitudinal profile, however, may have a negative impact on the use of TAS in the field when laid thicknesses in various regions exceed the limit. In such cases, either lower or higher compaction may have been attained, which may have a negative impact on the road's design life.

Variations in layer thickness brought on by constructive issues have an impact on the durability of the pavement structure. In this regard, a number of research studies comparing as-designed and as-built asphaltic pavement show a significant thickness variance between the two. Such changes exhibit a normal distribution; the trend is for thin layer thicknesses to be greater than those intended [27].

ABC (DGAB) is a frequently used base layer material and an important part of the pavement. Before spreading the asphalt mixture, a level survey of the base layer is conducted. Corrections are then performed until the level variances are within the acceptable range.

Field survey data on base layer are gathered to examine the impact of variation in the longitudinal profile of base layer in TAS. These layers are made for traditional asphalt pavement, where the asphalt mat is 50 mm thick. Every 10 meters along the length of the road, the level is tested three or five times, depending on the lane width. Levels are initially examined to ensure that they fall within the designated tolerance. If not, adjustments are done until the levels are within acceptable limits. Motor grader is then used to rectify initial readings that contain mistakes. For this investigation, level readings that were taken after the surface top level correction were taken into account.

For this study, a 25 mm TAS (DG10) thickness is proposed. The New Zealand Standard stipulates a tolerance for layer thickness of TAS of 5 mm. Additionally, the New Zealand requirement specifies that any TAS must be at least 20 mm thick. The +15mm/-10mm tolerance limit currently used in Sri Lanka may have an impact on the layer thickness of TAS.

In order to accomplish stable road construction measures, the objective of this study is to evaluate the effective thickness of TAS layers from design thickness, presuming that adequate execution of the construction process and quality control are supplied. In this study, the impact of TAS construction on the base layer is evaluated.

5.2 Statistical Analysis of exiting road condition.

5.2.1 Level Survey Data

Data collections has been done. for 11 road segments in 3 different road projects . Table 5.1 shows the surveyed segments and length of each road.

Levels are initially checked to be in between the tolerance specified. If not, corrections are made until levels are at satisfiable range using motor grader. All the surveyed level data are presented in Annex 2.

Table 5.1 Level Survey details

Road Name	District	surveyed Segments	Length (m)
WGA 291	Gampaha	0+400 - 0+990	590
WGA 293		0+030 - 1+390	1360
WGA 406		0+120 - 1+170	1050
WGA 049		0+010 - 0+990	980
WCO 120	Colombo	0+020 - 1+110	1090
WCO 263		1+750 - 2+790	1040
WCO 271		2+770 - 3+800	1030
EBT 007	Batticaloa	1+890 - 2+710 2+750 - 3+000	1070
EBT 192		3+430 - 4+090	660
EBT 027		0+250 - 0+500	250
EBT 036		0+710 - 1+390	680

The Figure 5.1, Figure 5.2 and Figure 5.3 shows the variation of level of longitudinal profile of a 200 m segment in EBT 007 as an example, prior and after the surface top level correction in left, right and center of road segment respectively.

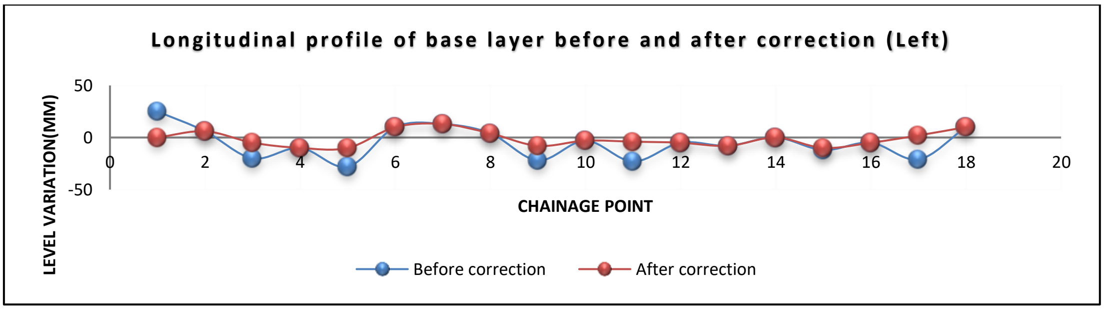

Figure 5.1 Longitudinal profile of base layer before and after correction (Left)

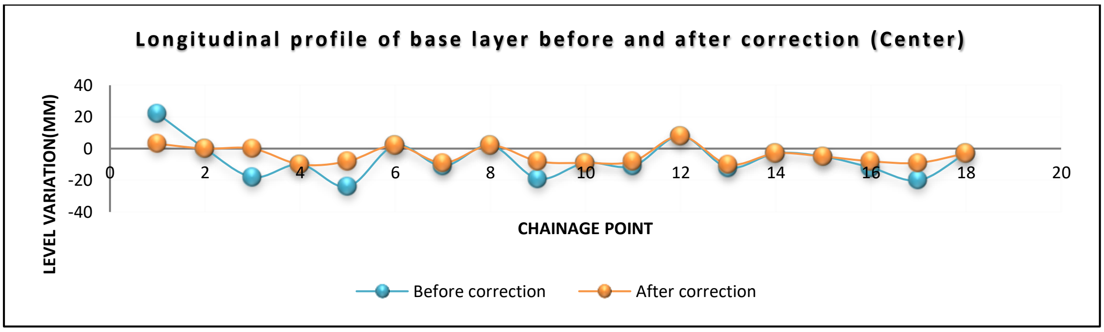

Figure 5.2 Longitudinal profile of base layer before and after correction (Center)

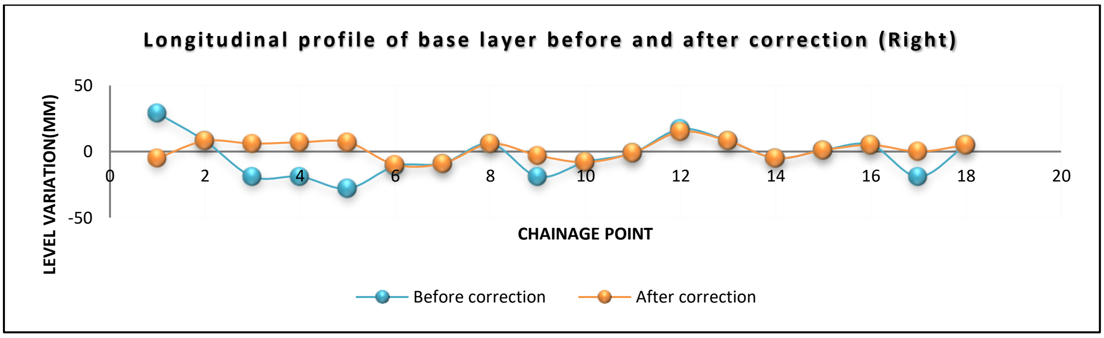

Figure 5.3 Longitudinal profile of base layer before and after correction (Right)

Because of the extra effort put out by construction workers in rectifying level fluctuations, there has been a large fluctuation, which is evident in these charts. These corrections are made accordance with the tolerance limit presented in ICATD SSCM.

5.3 Statistical Analysis and Discussion

It was assumed that top level of longitudinal profile for Asphalt concrete layer is constant and other factors same except for the top level of longitudinal profile of base layer.

Figure 5.4 illustrates how it will impact the 25 mm asphalt layer by showing the longitudinal profile of a 200 m stretch of road. At each 10 m location, three points (the center, left, and right) were taken into account. The asphalt layer is represented by the lines in the figure. The asphalt's minimum and maximum thicknesses are; the minimum is 10 mm and the maximum is 35 mm. In this example, the projected asphalt layer thickness falls within the acceptable range in 31%, exceeds the needed thickness at 43%, and falls below the required thickness at 26%, with the consideration of minimum required thickness being 20 mm and the maximum required thickness being 30 mm.

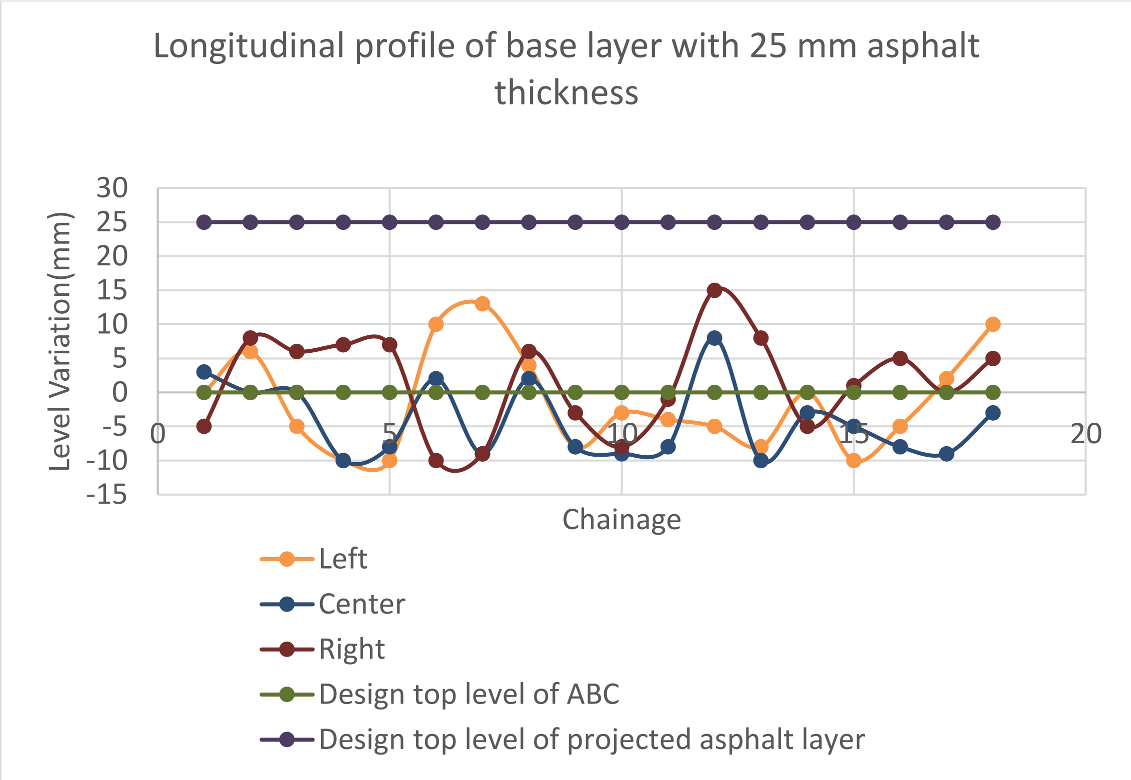

Figure 5.4 Longitudinal profile of base layer with 25 mm asphalt thickness

For that particular data example, a normal distribution curve was produced (refer Figure 5.6). The average thickness that was determined was 26.3 mm, with a standard deviation of 6.9 mm. The projected thickness ranges from 19.4 to 33.2 mm, or around 70% (Refer Figure 5.5).

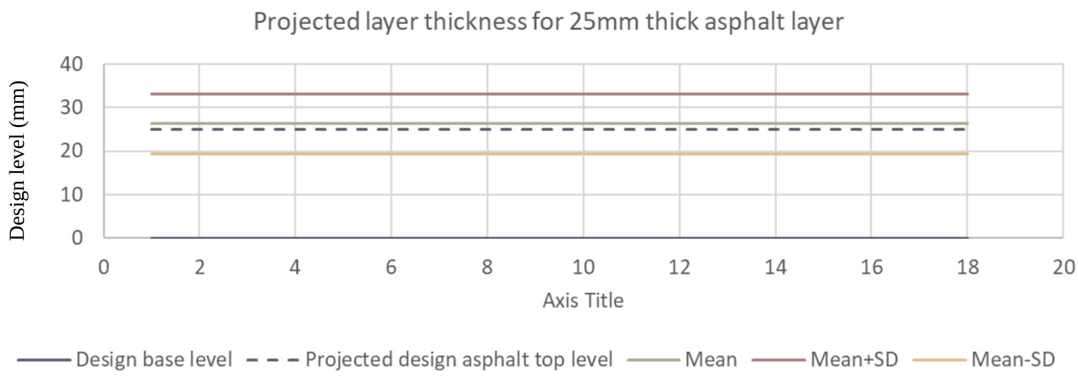

Figure 5.5 Projected layer thickness for 25mm thick asphalt layer

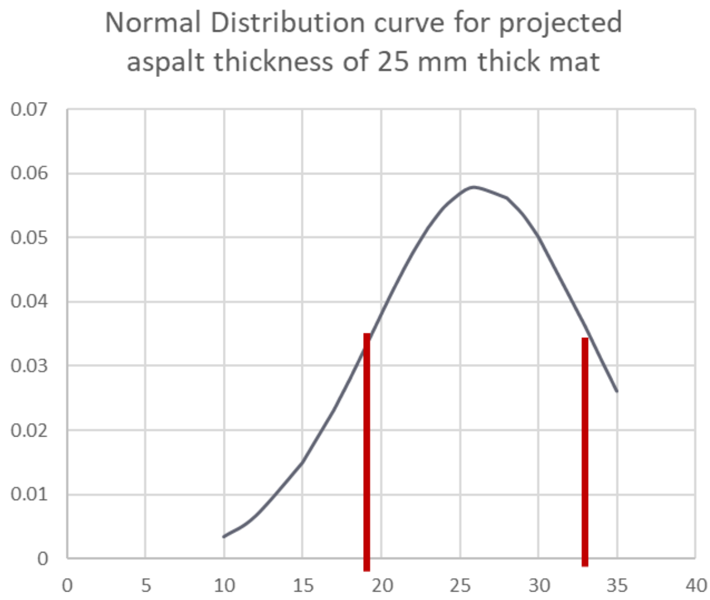

Figure 5.6 Normal distribution curve for projected asphalt thickness of 25 mm thick layer

The difference between mean and standard deviation values before and after the surface top level correction is displayed in Table 5.2. Standard deviation is significantly lower after applying surface top level correction than it was prior to it.

Table 5.2 Difference in mean and standard deviation values of base surface top correction prior and after the surface top level correction

Road Name	No. of locations surveyed (points)	Before level correction		After level correction	
		Mean (mm)	Standard deviation(mm)	Mean(mm)	Standard deviation(mm)
WGA 291	295	1.7	8.7	1.6	7.7
WGA 293	620	4.3	8.8	4.5	6.9
WGA 406	318	0.6	11.3	0.0	8.3
WGA 049	294	0.6	9.5	1.3	7.4
WCO 120	330	2.9	11.8	2.7	8.2
WCO 263	315	2.9	12.0	3.2	8.1
WCO 271	312	3.0	13.8	2.7	7.9
EBT 007	327	3.1	11.8	2.7	7.3
EBT 192	116	6.3	8.1	5.9	7.0
EBT 027	78	1.2	25.3	-0.5	8.9
EBT 036	207	6.0	7.7	5.4	6.5

Statistical evaluation was carried out for all surveyed roads. The Table 5.2 shows the mean and standard deviation values of projected asphalt thickness for all collected data of the relevant roads. For all of the roads surveyed, statistical analysis was carried out. The mean and standard deviation of the projected asphalt thickness for all data obtained to the relevant roadways are shown in the Figure 5.7. The mean asphalt thickness spans from 19.1 mm to 25.5 mm, with only 2 projects having less than 20 mm, while the standard deviation is between 6.8 and 8.9 mm. The mean plus or negative standard deviation values are derived from this data and then shown in the Figure 5.7.

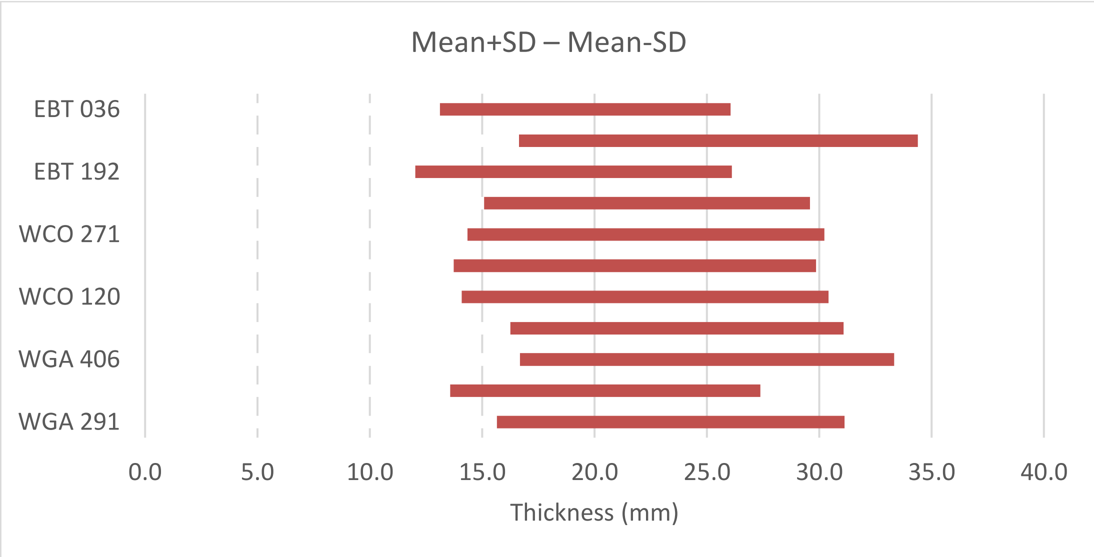

Figure 5.7 Mean+SD – Mean-SD diagram

The chart on Figure 5.7 shows almost 70% of projected thickness of asphalt layer with design thickness of 25mm, lies within the range that varies from 12.0-34.4mm.

5.4 Proposed options to meet the specified thickness condition required for TAS

The proposed options to meet the specified thickness conditions for TAS in this study are as follows

1. Increase the proposed layer thickness from 25mm to 30 mm.
2. Additional surface top level correction of base layer to meet the top level of longitudinal profile tolerance of ±10 mm.

5.4.1 Increase the proposed layer thickness from 25mm to 30 mm.

The maximum and minimum projected thicknesses will increase to 40 and 15 mm, respectively, if the layer thickness is increased from 25 to 30 mm (Refer Figure 5.8). This will considerably decrease the probability that a projected thickness of less than 20mm will occur.

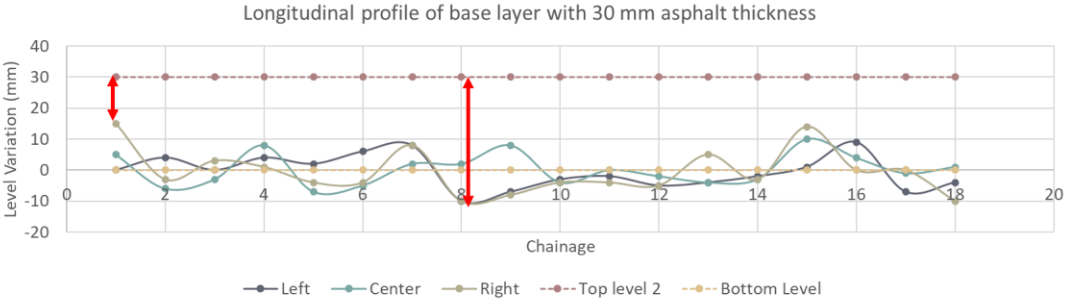

Figure 5.8 Longitudinal profile of base layer with 30 mm asphalt thickness

For layers that are 25 and 30 mm thick, Figure 5.9 displays the probability of projected thicknesses that are less than 20 and more than the thickness that is obtained by adding 5 mm. According to the Figure 5.9, when the thickness is increased to 30 from 25mm, as indicated, there is a significant decrease in the percentage of occurrence of predicted thickness less than 20.

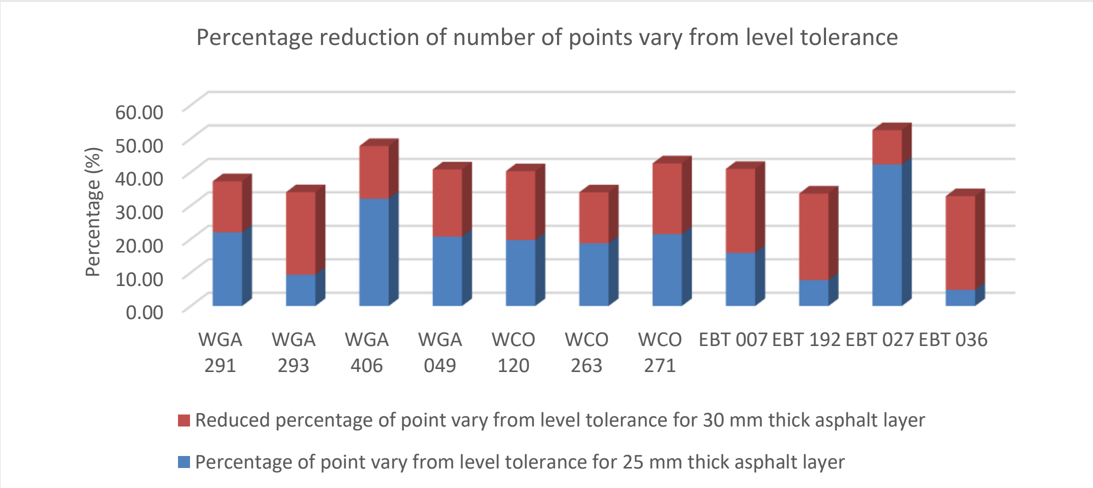

Figure 5.9 Percentage reduction of number of points vary from level tolerance

The difference is greater in the WGA 293 and EBT 007 and 192. In almost all of the roads described, the percentage of projected locations that deviate significantly from the tolerance for a 30 mm thick asphalt layer is low. This suggested that an asphalt layer 30 mm thick could be advantageous when taking the wearing course's structural capability into account. However, by meeting the structural need of thin wearing course, good workmanship and extra effort while constructing foundation layer can be further advantageous.

5.4.2 Additional surface top level correction of base layer to meet the top level of longitudinal profile tolerance of ±10 mm

Regarding the second alternative, additional surface top level adjustment of the base layer to meet the top level of longitudinal profile tolerance of ±10 mm, it can be seen that the probability of projected thickness less than 20 mm decrease significantly when the tolerance is reduced. This demonstrates the additional work that must be put into constructing the base layer before laying TAS.

When level tolerance is +15 / -10mm and 10mm, there is a considerable variation in the estimated percentage of places where surface top level correction is required as shown in Figure 5.10 and Table 5.3.

Table 5.3 Difference in the projected percentage of locations where surface top level correction is needed when level tolerance is +15 / -10mm and ±10 mm

Road Name	Percentage of Corrections	
	"+15"-"-10"	±10
WGA 291	13.22	25.76
WGA 293	11.13	30.00
WGA 406	19.18	28.30
WGA 049	11.22	22.45
WCO 120	22.73	40.30
WCO 263	20.63	39.68

WCO 271	29.81	41.03
EBT 007	23.85	37.61
EBT 192	10.34	31.90
EBT 027	60.26	65.38
EBT 036	6.76	29.47

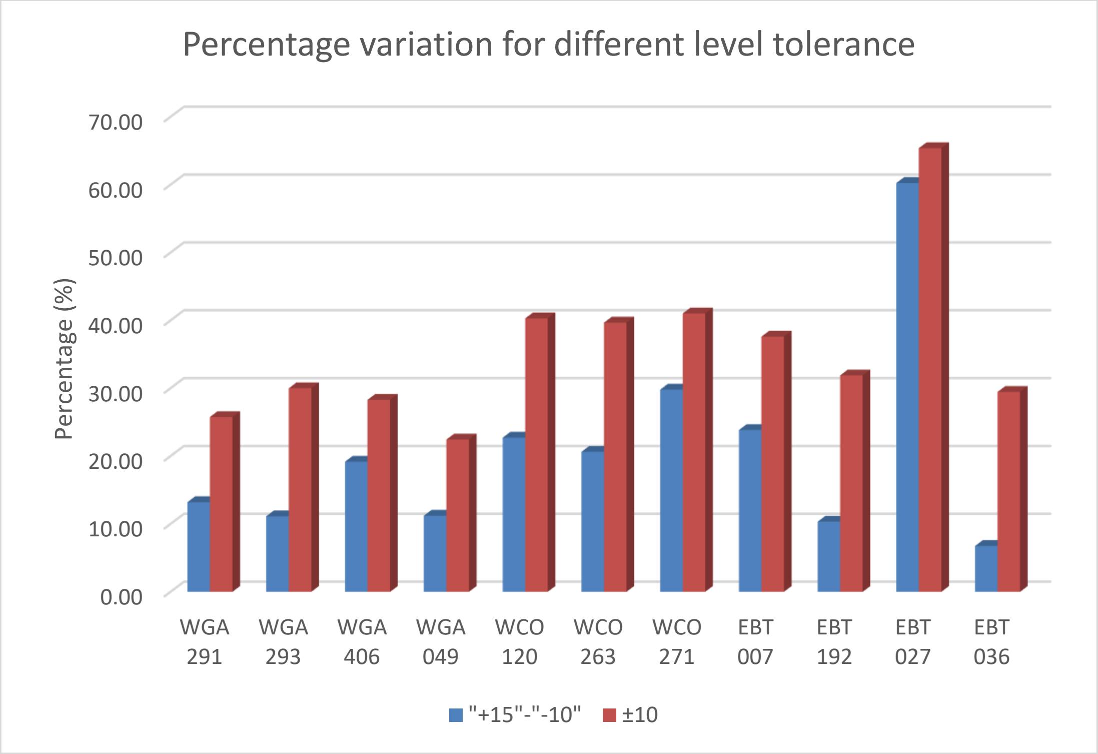

Figure 5.10 Percentage variation for different level tolerance

The estimated percentage of variation for the various level tolerance in WGA 293, WCO 120, and EBT 192 exhibits significant variations. The effort required for further base surface top level correction indicated the quality of the work on the current state of the road, and it can be completed with extra caution and under the proper supervision.

5.5 Summary

Base layer top level of longitudinal profile survey data was collected from various source. Projected asphalt concrete layer thicknesses were calculated and standard deviation and mean values of this thickness were calculated.

If the layer thickness is to be increased to 30 mm from 25mm, the maximum and minimum projected thickness will increase to 40 and 15 mm respectively. This will increase the probability of occurrence of projected thickness of less than 20mm significantly.

As for the second option, additional surface top level correction of base layer to meet the top-level tolerance of ±10 mm, it is observable that there is a significant increment in the percentage of occurrence of projected thickness less than 20mm when the tolerance is reduced. This shows the amount of addition effort that should be made in the construction of base layer before laying TAS.

This indicated that both methods can benefit considering deliver of structural capacity of the wearing course. However, good workmanship and additional effort while constructing base layer can be further beneficial by achieving the structural requirement of thin wearing course.

6 DETERMINATION OF EFFECT OF LAYER THICKNESS IN COMPACTION OF TAS UNDER LABORATORY CONDITIONS

6.1 Description

In Sri Lanka, HMA is the most widely used bituminous surface treatment because it offers excellent riding quality, durability, quick construction, and ease of building compared to other materials. HMA is more stable or rigid, resistant to harsh weather, and able to maintain constant quality throughout the production and laying processes. Because the asphalt covering layer serves as the pavement's main load bearing layer, the proper compaction of hot mix asphalt (HMA) pavement is essential.

The most important and closely related parameters for the compaction of HMA are rolling methods, techniques, mix temperature, mix properties, soundness and stiffness of the underlying foundation and type and quantity of rollers. The hot mixed asphalt concrete's ability to compress depends heavily on the temperature. The workability of HMA mixes is directly influenced by the compaction temperature of the HMA and the quality of the pavement in the field is directly impacted by the HMA laying process's compaction density.

Working under difficult construction conditions is frequently necessary due to the high demand for new asphalt pavements. The time available for compaction, the cooling rate, and the compaction process are all impacted by unfavorable conditions for HMA pavement, which include low air temperatures, strong winds, and nighttime construction. The local usage of the control mechanisms specified in the locally accepted standards normally occurs at the proper delivery and laying completion temperature. In countries with tropical climates, there are no particular elements relating to local conditions that may be used to anticipate these control aspects. This study looked at how local conditions like the environment, construction details, layer thickness, and material properties affect the cooling rate of the TAS pavement in order to determine the time available for compaction, which could lead to significantly better control during the compaction process in the local industry. As study parameters, environmental factors including layer thickness, base and ambient temperatures (morning, noon, and evening paving) will be used.

It is specified in the ICTAD's standard specifications that the lay-down temperature must not be less than 135°C. It is crucial to determine whether the time allowed for compaction is sufficient for Sri Lankan circumstances and regulations because TAS is a newer pavement technology in Sri Lanka. Due to the inability to appropriately densify the mix before it cools due to the rapidly decreasing mix temperature, thin layers are challenging to compact properly and attain the desired density.

Finding the time allowed for TAS layer compaction under the influence of thickness and base temperature is the primary objective of this research.

The layer temperature reduction was tested experimentally for various base temperature conditions and layer thicknesses. It was able to foresee the amount of time available for field compacting TAS. To track the rate at which the asphalt layer is cooling, laboratory-based experiments have been conducted.

This experiment also utilized the asphalt mixture made up of the bitumen and aggregates described in section 4.6.2. The asphalt mixture was made using an asphalt mixer and heated to 140 ºC.

A slab mold, steel rod compactor, and infrared thermometer are the three primary pieces of equipment used in temperature measurement tests. In a slab mold that was 25 cm wide, 25 cm long, and 5 cm tall, test samples were constructed. The form of an actual in-situ pavement was replicated using the slab mold. By tampering with a steel rod until the desired thickness was reached, the sample was compacted as shown in Figure 6.1. At the thicknesses of 20 mm, 25 mm, 30 mm, and 35 mm, the necessary weight of asphalt concrete mixture for the relevant thickness was weighed in balance and placed into the molds.

The temperature of the surrounding air was then measured using Mercury thermometer. Using an infrared thermometer, the temperature of the slab sample's surface and its center were monitored. Before applying the asphalt mixture, the base temperature of the surface and the ambient temperature were both monitored. An infrared thermometer was used to measure the sample temperatures (Refer Figure 6.2) at three different locations for each sample at regular intervals. The average slab surface readings were captured as a graph. Solar flux, base temperature, ambient temperature, and layer thickness were examined as influencing factors on the samples. Three separate times during the morning, noon, and evening were used to conduct the testing for the effects of solar flux, base, and ambient temperature outside the highway laboratory. To simulate both hot and cool daytime settings, samples were examined at 8 a.m., 12 p.m., and 4 p.m.

The experiment was conducted on a sunny day, and the steps above were repeated at several points throughout the day when the base temperature varied.

Figure 6.1 Preparation of sample on slab mould

Figure 6.2 Measurement of temperature of sample using IR thermometer

6.2 Results and Discussion

HMA stiffens and becomes more difficult to compact when it cools to room temperature, which could lead to insufficient compaction. The cooling of HMA throughout the paving process must therefore be carefully controlled to ensure that there is enough time for the compaction process to be completed. As can be observed in the section 2.6, the heat reduction rates for the layers with lower thicknesses were higher than those for layers with higher thicknesses, and these heat reduction curves varied depending on the base and air temperatures.

The temperature reduction of TAS is crucial at the early stage of laying, according to the cooling time graph that was plotted. The reading data used for this study is included in Annex 3.

The result of the time available for compaction (min) obtained from the cooling time graph drawn for each test in sections 6.3.1, 6.3.2 & 6.3.3 was used to determine the cooling rate for specific tests. Every discussion shows the temperature reduction at a particular air and base temperature, and the time needed for the sample to cool to 90 ^{o}C—the minimum temperature at which it is possible to compact asphalt based on ICTAD SSCM, was also taken into account. In Sri Lanka, the lower limit of the usual laydown temperature is typically around 140 ^{o}C or more. Therefore, it is considered as the laydown temperature for this study in order to determine the minimum available time for compaction. The sample's temperature was determined by averaging the three readings.

6.2.1 Case study 1

The conditions listed in Table 6.1, which were considered to be typical in Sri Lanka during a sunny day morning ideally reflecting cooler atmosphere, were followed when laying the asphalt mix. Utilizing the approach described in section 6.2 the samples were set out.

Table 6.1 Morning time environmental condition

Time	8.00 am
Base temperature	25

Air temperature	25

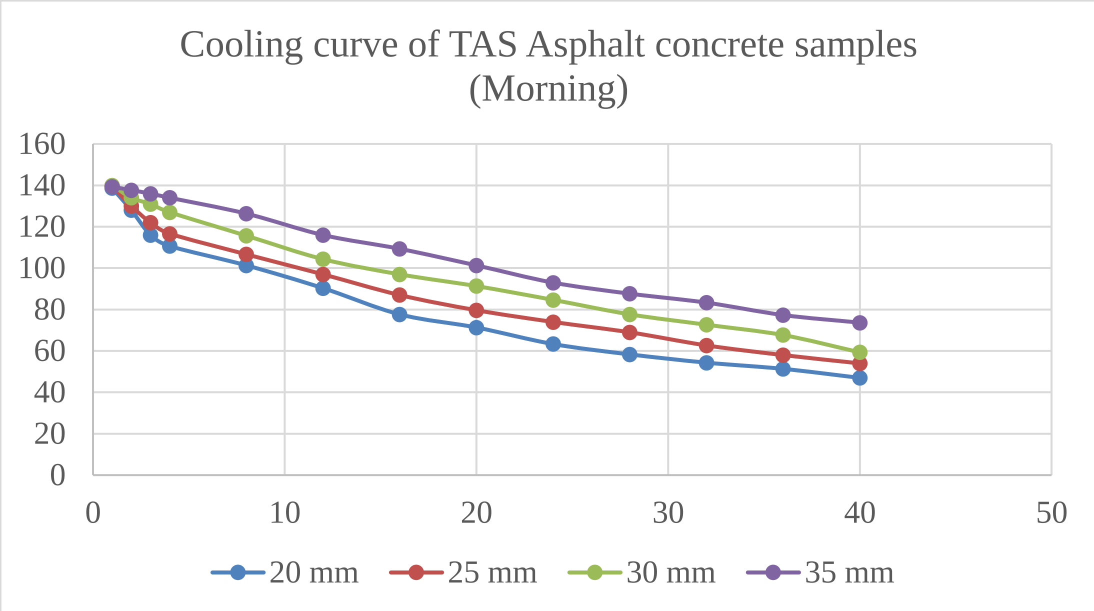

Figure 6.3 Cooling curve of TAS Asphalt concrete samples (Morning)

The cooling rate of asphalt concrete layers of various thicknesses, which were laid at 140 ºC. in the morning while the air temperature was 25 ºC and the base temperature was 25 ºC, is shown in Figure 6.3. In comparison to noon, the base temperature is cooler in the morning. The air temperature was 26 ºC, which was a little lower than the temperatures in the midday and late evening. In a typical sunny morning, it took 11, 15, 20, and 24 minutes for layers that were 20, 25, and 30 mm thick to reach 90 ºC.

6.2.2 Case study 2

The conditions listed in Table 6.2 Noon time environmental condition, which were considered to be typical in Sri Lanka during a sunny day noon and ideally indicating a hot climate, were observed when the asphalt mix was laid. Utilizing the approach described in section 6.2, the samples were laid down.

Table 6.2 Noon time environmental condition

Time	12.00 noon

Base temperature	52.5
Air temperature	27

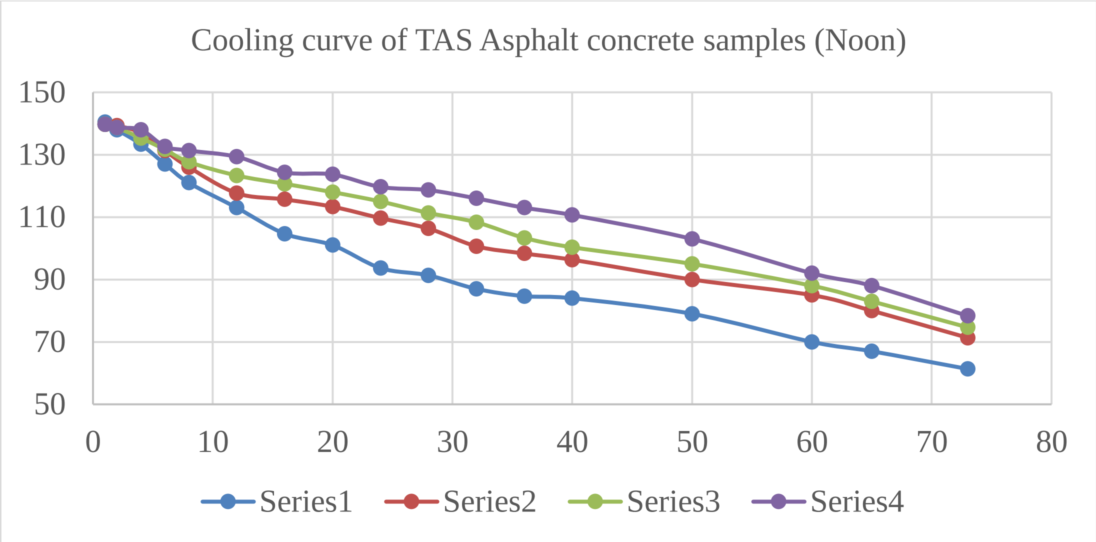

Figure 6.4 Cooling curve of TAS Asphalt concrete samples (Noon)

The cooling rate of asphalt concrete layers of various thicknesses, laid down at 140 ºC in the afternoon when the base temperature was 52.5 ºC and the air temperature was 27 ºC, is shown in Figure 6.4. In comparison to morning and evening, the base temperature is higher in the noon. The air temperature, which was somewhat higher than the morning and evening readings, was 27 ºC. The base was laid with an asphalt mixture on a sunny day in direct sunlight, resulting higher base and air temperatures. On a typical sunny noon, it took 29, 50, 65, and 72 minutes to attain 90 ºC for 20, 25, 30, and 35 mm thick layers, respectively.

6.2.3 Case study 3

The conditions listed in Table 6.3, which were thought to be typical for Sri Lanka during a sunny day evening and ideally indicating a slightly warm atmosphere, were followed when laying the asphalt mix. Utilizing the methodology described in section 6.2, the samples were set out.

Table 6.3 Evening time environmental condition

Time	4.00 pm
Base temperature	30.2
Air temperature	26

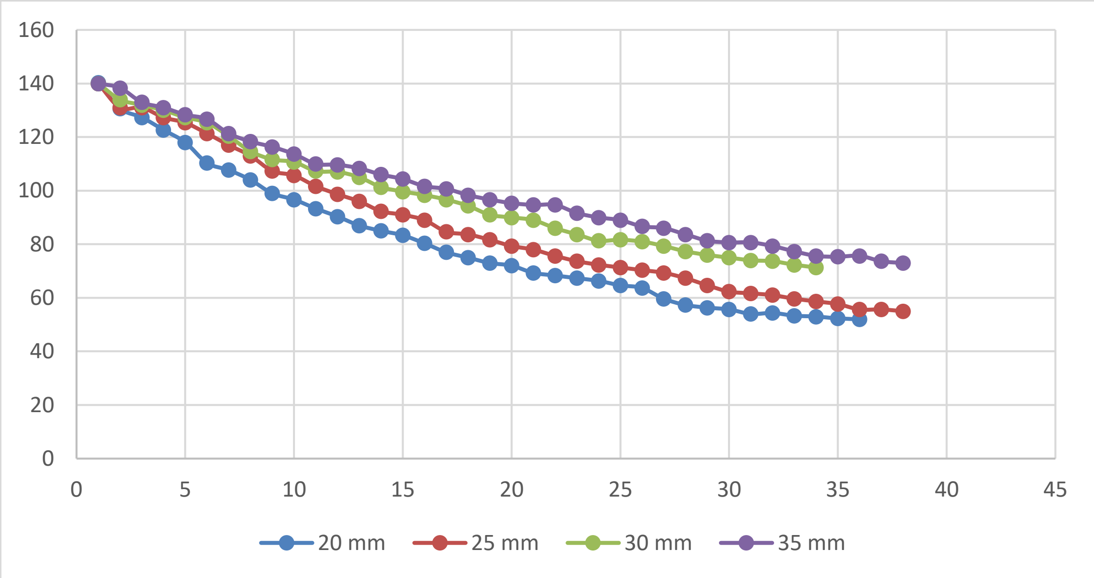

Figure 6.5 Cooling curve of TAS Asphalt concrete samples (Evening)

Figure 6.5 shows the rate of cooling of asphalt concrete layers of various thicknesses that were placed at 140 ⁰C in the evening when the base temperature was 30.2 ⁰C and the air temperature was 26 ⁰C, while the base temperature is slightly higher in the evening than it is in the morning, it is still lower than it is in the afternoon. The air temperature was 26 ⁰C, which was somewhat higher than morning temperatures and lower than noontime readings. For a 20 mm thick layer to reach 90 ⁰C on a typical sunny evening, it took 12, 16, 20, and 24 minutes, respectively.

6.3 Summary on laboratory based study on heat reduction rate of TAS

The results of the paving time test, which evaluated how surface and ambient temperature and solar flux affect the TAS cooling rate, reveal that paving work done at noon results in a lower cooling rate than work done at 8 a.m. and 4 p.m, because of the high solar flux as well as the surface and ambient temperatures at that time. The time that is available for compaction of TAS for various thicknesses and times of the day is summarized in Table 6.4.

Table 6.4 Summary of Time available for compaction

Asphalt concrete later thickness	Time available for compaction (min)		
	Morning	Noon	Evening
20 mm	11	27	12
25 mm	14	50	16
30 mm	19	65	20
35 mm	24	72	24

According to the test's findings, the least amount of time is available for compaction while paving at 8 a.m. This happened because the surface and ambient temperatures were lower than when paving at noon and evening. The findings of the compaction time at morning and evening are quite similar. This similarity demonstrates that the effect of solar flux on base temperature is more significant than that on mix temperature.

Paving projects completed during the midday have a slower cooling rate than those completed in the morning or evening, which allows for more time for TAS pavement compaction. This is because surface and ambient temperatures are frequently greater during the midday owing to solar radiation. Due to the lack of solar radiation and the lower surface and ambient temperatures at night, the pace of cooling will increase. The time available for compaction is shortened as a result.

The results of the experiments conducted showed that the length of time available for the TAS compaction process is significant since it depends on the cooling rate, which is readily influenced, particularly during colder climates. Two suggestions are provided in order to more effectively manage the time available for compaction in challenging circumstances: (1) compaction should be completed shortly after the laying process; and (2) the roller compactor should be placed immediately behind the paver to increase compaction and save time.

7 FIELD TRIAL

7.1 Site Selection

TAS is designed for low volume traffic; hence it was decided to select a road with low volume road in Gampaha district. Therefore, below site and contractor were selected.

- Selected Site - Gampaha road project
- Selected Contractor - ACCESS (Pvt.) Ltd
- Selected Plant - Kotadeniyava ACCESS Asphalt Plant (Figure 7.1)
- Road Id – WGA 199 (Dagonna Welamada road) (Figure 7.2)
- Laying section – 1+250 – 1+460 km
- Road width – 3 m

Figure 7.1 Kotadeniyawa asphalt plant

Figure 7.2 Selected site for TAS trial section (WGA 199)

7.2 Paving trial – Mix design

Paving trial asphalt mixture production was carried out in Kotadeniyava ACCESS Asphalt Plant where it is convenient to mix asphalt using relevant aggregates (**100% passing on 14 mm sieve**).

Initially aggregate blending calculation was carried out for the gradation provided by the plant. The blending proportions and blended gradations are shown in Figure 7.3. The hot bin proportions were 47%, 35% , 15% and 3% for Hot bins 1,2 3 and filler respectively, to achieve the effective gradation within limits as shown in Figure 7.3.

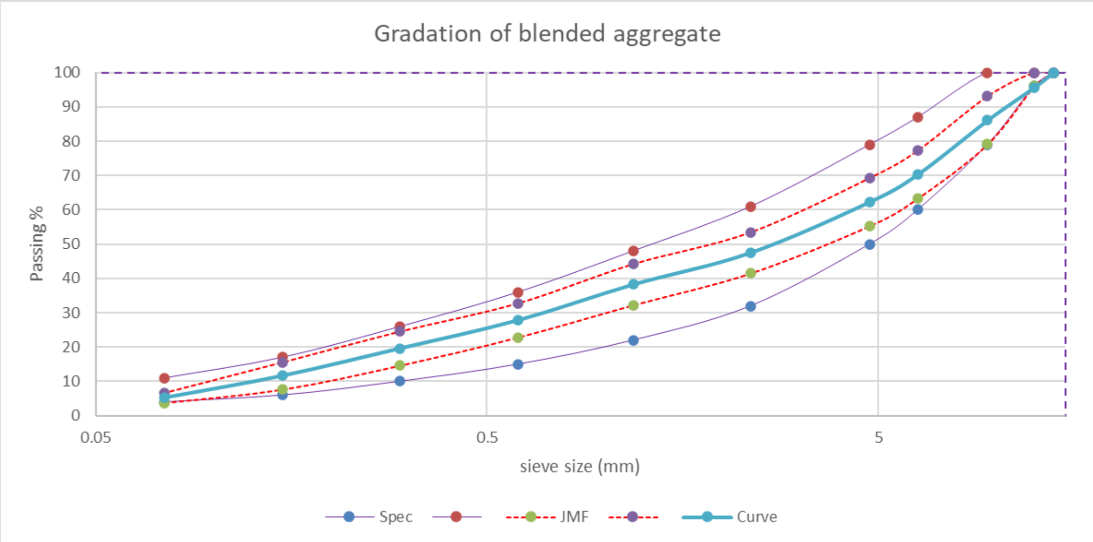

Figure 7.3 Gradation of blended aggregate for TAS mixture

In the Kotadeniyava Access plant, testing for Marshal properties was done after determining the blending proportions. Table 7.1 shows the relevant outcomes. The optimum bitumen content, according to these experimental findings, was 5.2%. For this bitumen content, every requirement was satisfactory.

Table 7.1 Marshal properties of Asphalt mixture used for TAS field trial

Bitumen Content	5.20%

Bulk density	2.476 g/cm3
Air voids	4.20%
VMA	15.85%
Stability	10.8 kN
Flow (0.25mm)	11.7

7.3 Construction Procedure

Construction was carried out in two sections

- Section 1 – 30 mm layer thickness (1+ 260 – 1+ 360)
- Section 2 – 25 mm layer thickness (1+370 – 1+460)

As shown in Figure 7.4, Section 1 was built with a 30 mm thickness, whereas Section 2 was built with a 25 mm thickness, with transition zones connecting the two parts. Additionally, it was decided to carry two separate zones in each section with a different number of roller passes in order to determine the ideal number of roller passes to accomplish the desired compaction. Table 7.2 lists the roller passes for relevant zones.

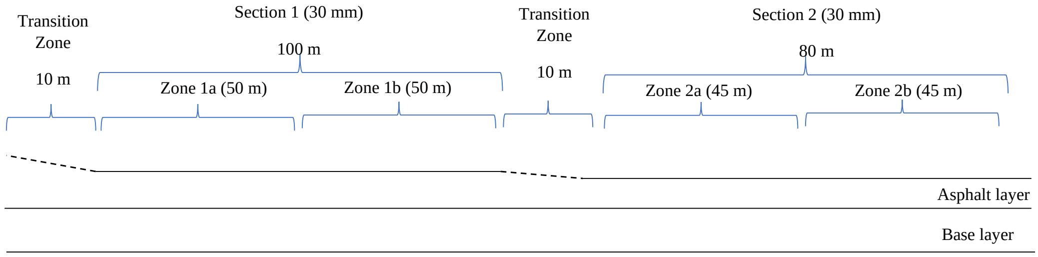

Figure 7.4 Profile of trial sections

Table 7.2 Number of roller passes selected for the trial

Roller	Section 1	Section 2

	Zone 1a	Zone 1b	Zone 2a	Zone 2b
Initial	2	2	2	2
Intermediate	14	12	10	8
Final	8	8	8	8

As a result, on June 20, 2022, TAS trail construction was completed on a road (ID - WGA 199) in the Gampaga district. On-site visual supervision was provided for each procedure. It was documented and evaluated how the density reading and temperature changed over time. The Kotadeniyawa Asphalt Plant produced asphalt mixtures using previously specified Design mix proportions.

Following procedures was carried out for ensuring the applicability of TAS

- Before construction
  - Base layer top level of longitudinal profile was surveyed. (For this trial, level was surveyed for each 1 m [left (1.0, 1.5), center and right (1.0, 1.5)] for more accuracy).
- After the construction
  - Top level of longitudinal profile of the paved asphalt layer was surveyed to check the asphalt thickness (Figure 7.5).
  - Core samples were taken from predetermined locations and thickness and compaction of the collected core samples need to be checked.

Figure 7.5 level reading at 1 m interval before asphalt laying

7.4 Thickness variations of laid asphalt surface

Measurements of the level reading before and after the installation of thin asphalt surfacing were used to determine the thicknesses in the appropriate spots. This is done to determine how changes in base layer level affect changes in asphalt concrete layer thickness in field. Level readings were obtained every meter along the longitudinal profile, every 1.5 meters on the RHS and LHS, along the transverse profile. There were 960 places total that were considered. The Table 7.3 & Table 7.4 provides an overview of the thickness for both 25 mm and 30 mm sections respectively.

Table 7.3 summary of layer thicknesses in 30 mm layer section (1+260 - 1+360)

Thickness	Number of locations	Percentage
< 20 mm	29	5.7
20 - 25 mm	32	6.3
25 - 30 mm	105	20.8
30 - 35 mm	163	32.3
35 - 40 mm	121	24.0
> 40 mm	55	10.9

Total points	**505**	
Average thickness	32.7	
Standard deviation	7.0	

Table 7.4 summary of layer thicknesses in 25 mm layer section (1+370 - 1+450)

Thickness	Number of locations	Percentage
< 20 mm	27	5.9
20 - 25 mm	61	13.4
25 - 30 mm	135	29.7
30 - 35 mm	117	25.8
> 35 mm	114	25.1
Total points	**454**	
Average thickness	**30.3**	
Standard deviation	**6.2**	

In comparison to the 25 mm segment, where an average thickness of 30.3 mm was attained under field conditions, the average thickness achieved in the 30 mm section is 32.7 mm, which is closer to the targeted layer thickness. In both portions, there are relatively the same number of locations with layer thicknesses of less than 20 mm. On the other hand, location where the layer thickness higher than the intended thickness is comparatively higher in 25 mm section and locations with layer thicknesses in between ±5 mm of the intended value is higher in 30 mm sections. Results for 30 mm layer thickness are more favorable under the test section's field circumstances.

The number of areas where the thickness of the asphalt concrete layer is greater than 40 mm can be decreased by reducing the loose asphalt concrete thickness while laying (from 37 to 35) and adjusting the top-level tolerance of base layer. Reducing the loose asphalt concrete mix thickness by 2 mm can cut the number of locations where the thickness is greater than 40 mm in half in the trial's 30 mm section.

7.5 Core details and Marshal properties of the trial mix.

Samples of asphalt mixture of trial TAS mixture was collected on site for laboratory based investigations and the summary is shown in the Table 7.5.

Table 7.5 Marshal density -TAS field trial

No	Thickness	In Air	In water	SSD	Marshall Density	Avg. Marshal Density
1	63.7	1267.6	758.6	1268.4	2.486	2.485
2	63.9	1268.5	758.7	1269.5	2.483	
3	64.0	1267.2	757.3	1267.5	2.484	

Core samples were collected from the laid road next day to identify the compaction of each section of the trial road section. The summary of the compaction details are shown in the Table 7.6.

Table 7.6 Core sample test detail - TAS field trial

Core No	**Location**	**Side**	**Offset (m)**	**Thickness (mm)**	**Core Density**	**Compaction (%)**	**Remarks**
1	1+274	LHS	1.2	43.0	2.396	96.4	30 mm Section 01 (1+260 - 1+340)
2	1+284	RHS	1.2	37.6	2.436	98.0	
3	1+295	LHS	1.3	32.6	2.397	96.5	
4	1+288	Center		35.6	2.469	99.3	
5	1+313	RHS	1.2	33.5	2.367	95.3	30 mm

6	1+325	LHS	1.3	33.9	2.386	96.0	Section 02 (1+300 - 1+340)
7	1+336	RHS	1.2	31.9	2.362	95.1	
8	1+323	Cente r		31.5	2.449	98.5	
9	1+356	LHS	1.2	30.9	2.374	95.5	25 mm Section 01 (1+300 - 1+390)
10	1+370	RHS	1.2	23.3	2.250	90.5	
11	1+385	LHS	1.4	23.1	2.285	92.0	
12	1+366	Cente r		26.2	2.318	93.3	
13	1+399	RHS	1.1	34.6	2.444	98.3	25 mm Section 02 (1+390 - 1+430)
14	1+423	LHS	1.3	35.9	2.385	94.9	
15	1+412	RHS	1.2	32.7	2.380	95.8	
16	1+416	Cente r		31.0	2.465	99.2	

Due to a lack of compaction time, some locations' compaction of the asphalt layer core did not meet requirements. Comparatively to the rest, section 1's (30 mm) level of compaction appeared to be satisfactory.

7.6 Temperature reading of asphalt layer

Temperature drop of asphalt layer surface with time was measured during the trial using an IR thermometer at 2 locations along with air and base temperatures. The measured readings are listed in the following Table 7.8 and Table 7.9 and Table 7.7 shows the site environment conditions and laydown temperature.

Table 7.7 Site temperature readings

Location	1+272 LHS
Base temperature	28
Air temperature	28

Laying temperature	146.9

Table 7.8 TAS surface temperature reading at location A (1+272 LHS)

Time (mins)	Temperature (⁰C)
0.00	146.9
7.30	109.3
9.42	113.5
11.02	102.8
15.10	93.8
18.32	81.8
20.28	80.7
30.53	72.7
35.20	68.7
37.20	65.7
45.20	61.2
49.20	59.3

Table 7.9 TAS Surface temperature reading at location B (1+272 RHS)

Time (mins)	Temperature (⁰C)
0.00	149.6
4.25	122
7.40	118.3
8.50	113.3
12.00	106.6
12.40	105.2
13.55	100.7
16.31	95.2
17.38	91.4
21.09	83.3

22.06	81.3
23.18	80.7
31.60	74.4
39.20	67.6
43.40	65.8

From the Table 7.8 and Table 7.9 it can be seen that the time available for compaction is under 20 minutes. Even though with the available technologies, it can be difficult to achieve desired compaction level, for the compaction procedures were not initiated right behind the paver.

7.7 Summary on Field Trial

- 30 mm section is more practicable than of 25 mm section
    - As of current practices, 30 mm section has lesser thickness variation and in case of heat loss, 30 mm layer can hold heat for longer than of 25 mm thick layer.
- Maintain loose asphalt thickness by 35 mm for 30 mm section.
    - As a result, there will be less chance that the layer thickness will be larger than 40 mm, decreasing asphalt waste.
- Limit the top level of longitudinal profile tolerance of base layer as ±10 mm (if possible ±7 mm).
- Usage of two pneumatic tire roller parallelly during the intermediate roller compaction.
    - As the heat loss is relatively high in thin asphalt surface than traditional asphalt surfacing, usage of two intermediate tire roller parallelly will help achieve the required compaction in time.
- As zone 1a (2-initial, 14 intermediate & 8 finishing roller) has shown more favourable results, it is recommended to use the same roller combination for test section as well.
- It is highly recommended to commence compaction procedures as soon as the asphalt truck arrives at site and asphalt concrete is laid.

8 CONCLUSIONS

It is crucial to put into practice an economically viable option for the building of asphalt pavements since LVR development is crucial for the expansion of the nation's economy. The minimum thickness for asphalt pavement is 50mm for typical asphalt pavement, according to Sri Lankan requirements for road construction and maintenance. Normal Traditional asphalt is regarded as durable but costs more, requires more resources, and is not required for LVR. Therefore, it's crucial to utilize the resources at hand effectively. The idea of thin asphalt surfacing is very new to Sri Lanka, and the gradation standards for TAS differ from conventional asphalting methods. Because of this, there has been healthy competition among manufacturers and designers to come up with the greatest surface layer design. Local resources may be used to produce TAS, according to laboratory studies conducted in Sri Lanka, and this study focuses on the field application of TAS. Few problems that could affect the TAS field experiment were found when field application of this new technology was taken into account. Such as the variation in gradation within the limit may have a negative impact on the characteristics of the asphalt mix, the top level of longitudinal profile tolerance may have an impact on the actual thickness of the asphalt mat, and an asphalt layer that is thinner than what is currently practiced may have a higher rate of heat reduction.

Investigations were done to determine the effects of coarse and fine gradation on Marshall Properties by dividing the gradation boundaries into two portions. The grades that were selected to represent the top and lower bounds of the necessary range were Gradation 1, which had more coarse material, and Gradation 2, which contained more finer material. To determine the impact of aggregate type and gradation variation, the test results from the Marshal Test were examined. According to a research that takes into account how several mixture properties, such air voids, VMA, stability, flow, density, and Marshall density, might vary. While testing the upper and lower gradation mixes at the appropriate optimal bitumen concentration, all required requirements were met. It is reasonable to assume that TAS mixing can be used to account for variation of particle sizes in selected gradations. For gradation

1 mixtures, the optimum bitumen contend was 6.4%, while for gradation 2 it was 6.37%.

Tolerances are permissible constructive deviances in the layer thicknesses of the pavement from the thicknesses stipulated during the design phase. To investigate the effects of variations in the longitudinal profile of base layer in TAS, field survey data on base layer were collected. These layers are designed for conventional asphalt pavement, which has a 50 mm-thick asphalt mat. Levels were first checked to see if they are within the specified tolerance. Levels were initially examined to ensure that they fall within the designated tolerance. If not, adjustments were done until the levels are within acceptable limits. To investigate the effects of variations in the longitudinal profile of base layer in TAS, field survey data on base layer are collected. Data gathering were completed. for 3 distinct road projects, 11 different road segments. The maximum anticipated thicknesses would rise to 40 and lowest anticipated thicknesses would rise to 15 mm, if the layer thickness were raised from 25 to 30 mm. This would considerably improve the likelihood that a projected thickness less than 20mm to occur. Regarding the second alternative, extra surface top level correction of the base layer to satisfy the top-level tolerance of ±10 mm, it can be seen that the probability of projected thickness is less than 20 mm increasing significantly as the tolerance is reduced. This demonstrates the additional work that must be put into building the foundation layer before installing TAS. However, by meeting the structural need of thin wearing course, good workmanship and extra effort when constructing foundation layer might be further advantageous.

The outcomes of the experiments conducted demonstrated the importance of the amount of time available for the TAS compaction process since it is dependent on the cooling rate, which is easily changed, especially in colder locations. The results of the test showed that paving around 8 a.m. leaves the least amount of time for compaction. This occurred because the temperature of the ground and the surrounding air was lower than when paving during the day and at night. Findings on the compaction time in the morning and evening were quite similar. This similarity shows that base temperature is more significantly impacted by solar flux than mix temperature is. Paving projects completed at noon have a slower cooling rate than those completed in the morning or evening because of the greater surface and ambient temperatures caused by solar radiation. This allows for more time for TAS pavement compaction.

TAS is made for low volume traffic, hence it was decided to choose a road in the Gampaha district with low volume traffic. For each segment, two alternative roller patterns were used. This is done to ascertain how variations in the base layer level effect variations in the thickness of the asphalt concrete layer. Under the test section's field conditions, the results for 30 mm layer thickness showed better outcomes. Some core samples collected from the asphalt layer did not meet specifications due to a shortage of compaction time. Section 1 with 30 mm layer showed an acceptable level of compaction in relation to the rest. The time allowed for compaction is less than 20 minutes, and the temperature reduction of the asphalt layer surface over time was observed during the trial using an IR thermometer. Although there are technologies available, it can be challenging to obtain the necessary compaction level if the compaction processes were not started immediately behind the paver.

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ANNEXURE A:

Marshal Properties results sheet

Gradation 1

Diameter				Height					Stability corrected factor	Dry weight (g)	Submerged Weight (g)	Surface saturated Weight (g)	Stablity		Flow	Volume (cm3)	Bulk specific gravity of compacted mix (Gmb)	Flow	Avg Flow	Corrected Stability	Avg Stability
D1	*D2*	*D3*	*D4*	*H1*	*H2*	*H3*	*H4*	*Avg*					Reading	KN							
101	101.4	101	101.4	66	67.2	66	66	66.3	0.93	1200.04	758.7	1253.6	57	6.6	2.8	533.36	2.4248	11.200		6.14	
102.45	102	102.45	102	64.4	65	66.1	65.9	65.35	0.91	1161.09	693.08	1177.33	28	3.3	2.3	536.42	2.3977	9.200	10.00	3.00	6.15
101.7	101.7	101.6	101.6	68.45	67.2	68	66.85	67.625	1	1244.89	749.53	1251.34	79	9.3	2.4	548.87	2.4808	9.600		9.30	
102	101	101	102	72.7	72.4	72	72.15	72.313	0.9	1179.04	701.56	1200.98	14	1.6	2.3	585.18	2.3608	9.200		1.44	
101.6	101	101.6	101	67.45	68.95	69	69	68.6	0.91	1249.1	749.8	1255.95	80	10	2.6	552.95	2.4678	10.400	10.40	9.10	6.56
101.7	101.7	101.7	101.7	65.5	66.6	66.6	65	65.925	0.88	1247.8	770.6	1249.81	89	10.4	2.9	535.60	2.6039	11.600		9.15	
101.2	101.95	101.2	101.95	67	68.35	68.55	67.7	67.9	0.92	1250.22	762.75	1254.25	69	8.1	2.9	550.29	2.5437	11.600	12.00	7.45	6.79
101	101	101	101	65.35	66.4	66.6	65	65.838	0.91	1246.57	772.26	1247.82	100	11.7	3.3	527.55	2.6213	13.200		10.65	

101.35	**100.5**	**100.5**	**101.35**	**69**	**70.25**	**69.95**	**68.55**	**69.438**	**0.87**	**1175.6**	**710.6**	**1195.85**	**22**	**2.6**	**2.8**	**555.57**	**2.4227**	**11.200**		**2.26**
101.4	**101.4**	**99.85**	**99.85**	**68.3**	**70**	**69.9**	**67.4**	**68.9**	**0.9**	**1168.21**	**700.07**	**1185.76**	**19**	**2.2**	**4.2**	**548.00**	**2.4053**	**16.800**		**1.98**
101.4	**101.3**	**101.4**	**101.3**	**71.3**	**70.1**	**71.2**	**72.2**	**71.2**	**0.9**	**1246.4**	**756.85**	**1264.08**	**40**	**4.6**	**3.3**	**574.48**	**2.4573**	**13.200**	**13.20**	**4.14**	**5.60**
101	**101.35**	**101**	**101.35**	**65.9**	**63.95**	**65**	**66.35**	**65.3**	**0.89**	**1242.64**	**768.28**	**1243.49**	**102**	**12**	**2.4**	**525.06**	**2.6149**	**9.600**		**10.68**	

Gradation 2

	Stability corrected factor	**Dry weight (g)**	**Submerged Weight (g)**	**Surface saturated Weight (g)**	**Stablity**		**Flow**	**Volume (cm3)**	**Bulk specific gravity of compacted mix (Gmb)**	**Flow**	**Avg Flow**	**Corrected Stability**	Avg Stability
Avg					**Reading**	**KN**							
66.3	0.93	1200.04	748.7	1253.6	57	6.6	2.8	533.36	2.3768	11.200		6.14	
65.35	0.96	1161.09	683.08	1177.33	28	3.3	2.3	536.42	2.3492	9.200	10.00	3.17	6.02
67.625	0.94	1244.89	739.53	1251.34	79	9.3	2.4	548.87	2.4323	9.600		8.74	
72.313	0.83	1179.04	691.56	1200.98	14	1.6	2.3	585.18	2.3145	9.200		1.33	
68.6	0.89	1249.1	739.8	1255.95	80	10	2.6	552.95	2.4200	10.400	10.40	8.90	6.74
65.925	0.96	1247.8	750.6	1249.81	89	10.4	2.9	535.60	2.4995	11.600		9.98	
67.9	0.95	1250.22	742.75	1254.25	69	8.1	2.9	550.29	2.4442	11.600		7.70	
65.838	0.96	1246.57	752.26	1247.82	100	11.7	3.3	527.55	2.5155	13.200	12.00	11.23	7.05
69.438	0.86	1175.6	690.6	1195.85	22	2.6	2.8	555.57	2.3268	11.200		2.24	
68.9	0.93	1168.21	685.07	1185.76	19	2.2	4.2	548.00	2.3332	16.800	13.20	2.05	6.09
71.2	0.92	1246.4	741.85	1264.08	40	4.6	3.3	574.48	2.3867	13.200		4.23	

65.3	1	1242.64	753.28	1243.49	102	12	2.4	525.06	2.5349	9.600		12.00	

ANNEXURE 2

Level Survey Data sheet and projected asphalt concrete layer thickness

WGA - 291 (Buthpitiya ginigesma road)

ABC Top level sheet (Rural Road in Gampaha District - Western province- package - 1)															
WGA - 291 (Buthpitiya ginigesma road)															
	Before Correction (mm)					**After correction (mm)**					**Projected asphalt concrete layer thickness (25 mm) (mm)**				
Chainage	**LHS**		**CL**	**RHS**		**LHS**		**CL**	**RHS**		**LHS**		**CL**	**RHS**	
0+400															
0+410	8	13	10	7	-5	8	13	10	7	-5	33	38	35	32	20
0+420	0	5	7	10	0	0	5	7	10	0	25	30	32	35	25
0+430	0	10	2	8	-1	0	10	2	8	-1	25	35	27	33	24
0+440	5	13	6	16	26	5	13	6	-3	-3	30	38	31	22	22
0+450	15	21	12	1	19	15	12	12	2	-3	40	37	37	27	22
0+460	3	17	15	15	-2	3	15	15	15	-2	28	40	40	40	23
0+470	-1	4	10	14	7	-1	4	10	14	7	24	29	35	39	32
0+480	4	10	3	12	20	4	10	3	12	11	29	35	28	37	36
0+490	5	6	-3	12	15	5	6	-3	12	15	30	31	22	37	40
0+500	8	10	3	15	14	8	10	3	15	14	33	35	28	40	39
0+510	4	11	-3	1	5	4	11	-3	1	5	29	36	22	26	30
0+520	0	0	-5	-12	-13	0	0	-5	-12	-13	25	25	20	13	12
0+530	8	14	15	8	0	8	14	15	8	0	33	39	40	33	25
0+540	6	15	13	4	-12	6	15	13	4	-12	31	40	38	29	13
0+550	6	2	6	1	-8	6	2	6	1	-8	31	27	31	26	17
0+560	17	9	8	9	2	15	9	8	9	2	40	34	33	34	27
0+570	2	12	5	2	0	2	12	5	2	0	27	37	30	27	25

0+580	0	6	-7	-1	-3	0	6	-7	-1	-3	25	31	18	24	22
0+590	4	8	5	-2	-4	4	8	5	-2	-4	29	33	30	23	21
0+600	-3	3	3	0	-7	-3	3	3	0	-7	22	28	28	25	18
0+610	-1	-5	4	-5	-7	-1	-5	4	-5	-7	24	20	29	20	18
0+620	-1	6	-3	5	-3	-1	6	-3	5	-3	24	31	22	30	22
0+630	-8	-8	-11	-2	0	-8	-8	-11	-2	0	17	17	14	23	25
0+640	2	1	-11	-4	-10	2	1	-11	-4	-10	27	26	14	21	15
0+650	11	2	-8	-5	-3	11	2	-8	-5	-3	36	27	17	20	22
0+660	12	3	-6	-6	-12	12	3	-6	-6	-8	37	28	19	19	17
0+670	-3	-6	-12	-7	4	-3	-6	-12	-7	4	22	19	13	18	29
0+680	-6	1	-9	-1	11	-6	1	-9	-1	11	19	26	16	24	36
0+690	2	5	-10	0	6	2	5	-10	0	6	27	30	15	25	31
0+700	3	8	-9	0	16	3	8	-9	0	15	28	33	16	25	40
0+710	9	9	9	5	-1	9	9	9	5	-1	34	34	34	30	24
0+720	16	16	13	3	-2	15	15	13	3	-2	40	40	38	28	23
0+730	8	12	11	5	-5	8	12	11	5	-5	33	37	36	30	20
0+740	-3	3	-5	-1	-8	-3	3	-5	-1	-8	22	28	20	24	17
0+750	4	3	-4	-2	-8	4	3	-4	-2	-8	29	28	21	23	17
0+760	5	-6	-19	-14	-6	5	-6	-7	-10	-6	30	19	18	15	19
0+770	-3	-4	-2	3	4	-3	-4	-2	3	4	22	21	23	28	29
0+780	-16	-7	-5	3	-5	-8	-7	-5	3	-5	17	18	20	28	20
0+790	-2	0	0	1	-4	-2	0	0	1	-4	23	25	25	26	21
0+800	3	12	14	8	-1	3	12	14	8	-1	28	37	39	33	24
0+810	-10	14	16	20	15	-10	14	15	13	15	15	39	40	38	40
0+820	18	15	14	9	5	13	15	14	9	5	38	40	39	34	30
0+830	-4	-4	-7	-4	-12	-4	-4	-7	-4	-12	21	21	18	21	13
0+840	7	6	-11	9	6	7	6	-11	9	6	32	31	14	34	31

0+850	-3	2	-10	-10	-8	-3	2	-10	-10	-8	22	27	15	15	17
0+860	-5	-3	-4	-7	-13	-5	-3	-4	-7	-13	20	22	21	18	12
0+870	6	15	21	13	3	6	15	12	13	3	31	40	37	38	28
0+880	-19	-14	-9	-9	-7	-5	-7	-9	-9	-7	20	18	16	16	18
0+890	-9	1	4	-6	-6	-9	1	4	-6	-6	16	26	29	19	19
0+900	16	15	15	12	17	15	15	15	12	15	40	40	40	37	40
0+910	7	8	-1	6	-1	7	8	-1	6	-1	32	33	24	31	24
0+920	2	-6	-13	-8	-4	2	-6	-13	-8	-4	27	19	12	17	21
0+930	-9	-14	-14	-16	-17	-9	-7	-10	-9	-8	16	18	15	16	17
0+940	5	-10	-16	6	7	5	-10	-8	6	7	30	15	17	31	32
0+950	2	-3	-7	-10	-8	2	-3	-7	-10	-8	27	22	18	15	17
0+960	2	-1	-11	-6	-6	2	-1	-11	-6	-6	27	24	14	19	19
0+970	7	12	3	-1	-11	7	12	3	-1	-11	32	37	28	24	14
0+980	1	3	15	9	-5	1	3	15	9	-5	26	28	40	34	20
0+990	-7	-4	-4	1	1	-7	-4	-4	1	1	18	21	21	26	26

WGA - 293 (Kirikitta Onauwkanda road)

ABC Top level sheet (Rural Road in Gampaha District - Western province- package - 1)															
WGA - 293 (Kirikitta Onauwkanda road)															
	Before Correction (mm)					**After correction (mm)**					**Projected asphalt concrete layer thickness (25 mm) (mm)**				
Chainage	**LHS**		**CL**	**RHS**		**LHS**		**CL**	**RHS**		**LHS**		**CL**	**RHS**	
0+030	-40	-10	-4	-7	-13	-15	-8	-4	-8	-10	10	17	21	17	15
0+040	-2	13	13	9	3	-2	13	13	9	3	23	38	38	34	28
0+05	8	15	-1	2	5	8	15	-1	2	5	33	40	24	27	30

0															
0+060	13	17	1	10	9	10	12	1	12	6	35	37	26	37	31
0+070	6	11	-1	8	15	13	11	5	10	6	38	36	30	35	31
0+080	17	10	4	6	8	15	10	4	6	8	40	35	29	31	33
0+090	-9	5	6	4	6	-9	5	6	4	6	16	30	31	29	31
0+100	12	16	15	10	10	13	12	-4	11	12	38	37	21	36	37
0+110	15	17	10	8	9	10	12	11	7	8	35	37	36	32	33
0+120	17	17	2	7	6	14	14	4	8	4	39	39	29	33	29
0+130	13	19	9	9	-5	11	15	11	10	-5	36	40	36	35	20
0+140	-7	6	1	8	5	-7	6	1	8	5	18	31	26	33	30
0+150	13	10	3	22	2	10	11	2	2	4	35	36	27	27	29
0+160	9	17	14	14	12	7	15	11	13	11	32	40	36	38	36
0+170	-30	-5	-6	5	1	-11	-6	-6	6	4	14	19	19	31	29
0+180	7	16	13	18	10	8	13	10	12	10	33	38	35	37	35
0+190	10	14	6	9	-4	10	14	6	9	-4	35	39	31	34	21
0+200	-6	-1	-10	0	-4	-6	-1	-10	0	-4	19	24	15	25	21
0+300	-14	-17	-18	-3	13	-9	-10	-10	-3	11	16	15	15	22	36
0+310	5	2	0	1	4	5	2	0	1	4	30	27	25	26	29
0+32	14	8	1	1	-1	14	8	1	1	-1	39	33	26	26	24

0															
0+330	2	1	0	6	-4	2	1	0	6	-4	27	26	25	31	21
0+340	2	7	4	10	18	3	4	4	8	3	28	29	29	33	28
0+350	10	4	-1	17	21	9	3	0	11	6	34	28	25	36	31
0+360	2	9	0	15	7	2	9	0	15	7	27	34	25	40	32
0+370	-6	7	-6	14	17	-3	-7	-1	10	13	22	18	24	35	38
0+380	5	6	5	27	31	5	7	7	7	14	30	32	32	32	39
0+390	14	5	-4	11	19	14	4	-6	9	10	39	29	19	34	35
0+400	9	3	-7	3	-7	9	3	-7	3	-7	34	28	18	28	18
0+410	21	10	-2	13	15	11	10	-3	10	15	36	35	22	35	40
0+420	-23	-14	-7	8	11	-6	-1	-6	10	7	19	24	19	35	32
0+430	-3	0	4	21	6	-3	1	5	9	13	22	26	30	34	38
0+440	11	3	-3	13	16	12	2	-3	7	-2	37	27	22	32	23
0+450	-10	-5	-2	11	11	-10	-5	-2	11	11	15	20	23	36	36
0+460	6	3	-4	5	0	6	3	-4	5	0	31	28	21	30	25
0+470	6	-2	-7	3	-7	6	-2	-7	3	-7	31	23	18	28	18
0+480	-10	-5	0	-2	-13	-10	-5	0	-2	-13	15	20	25	23	12
0+490	2	7	6	3	-9	2	7	6	3	-9	27	32	31	28	16
0+51	13	2	-	-5	0	13	2	-	-5	0	38	27	14	20	25

0			11					11							
0+520	13	10	2	8	8	13	10	2	8	8	38	35	27	33	33
0+530	-3	8	5	12	12	-3	8	5	12	12	22	33	30	37	37
0+540	11	7	11	1	9	11	7	11	1	9	36	32	36	26	34
0+550	5	2	5	9	13	5	2	5	9	13	30	27	30	34	38
0+560	5	4	0	6	-1	5	4	0	6	-1	30	29	25	31	24
0+570	9	12	1	3	5	9	12	1	3	5	34	37	26	28	30
0+580	10	12	13	11	-9	10	12	13	11	-9	35	37	38	36	16
0+590	-3	9	11	11	12	-3	9	11	11	12	22	34	36	36	37
0+600	-9	0	4	4	-3	-9	0	4	4	-3	16	25	29	29	22
0+610	1	2	-5	-2	9	1	2	-5	-2	9	26	27	20	23	34
0+620	-3	-1	8	3	10	-3	-1	8	3	10	22	24	33	28	35
0+630	4	7	-15	-12	2	4	7	-15	-12	2	29	32	10	13	27
0+640	4	10	3	13	5	4	10	3	13	5	29	35	28	38	30
0+650	14	12	3	9	12	14	12	3	9	12	39	37	28	34	37
0+660	24	16	-2	8	1	9	14	-2	8	1	34	39	23	33	26
0+670	-26	-9	-6	11	12	12	5	-6	11	12	37	30	19	36	37
0+680	9	5	-5	4	-5	9	5	-5	4	-5	34	30	20	29	20
0+69	-3	3	7	10	-9	-3	3	7	10	-9	22	28	32	35	16

0															
0+700	9	9	-7	12	14	9	9	-7	12	14	34	34	18	37	39
0+710	12	12	-6	21	3	12	12	-6	15	3	37	37	19	40	28
0+720	8	4	-6	3	8	8	4	-6	3	8	33	29	19	28	33
0+730	-1	5	0	3	-3	-1	5	0	3	-3	24	30	25	28	22
0+740	-6	-5	-5	10	6	-6	-5	-5	10	6	19	20	20	35	31
0+750	-28	-15	-15	3	3	10	-1	-4	1	1	35	24	21	26	26
0+760	-17	1	11	14	10	1	1	11	14	10	26	26	36	39	35
0+770	-7	-6	-1	3	6	-6	6	0	14	10	19	31	25	39	35
0+780	5	9	5	1	-8	5	9	5	1	-8	30	34	30	26	17
0+790	32	28	5	16	5	15	15	5	15	5	40	40	30	40	30
0+800	-2	11	4	9	8	-2	11	4	9	8	23	36	29	34	33
0+810	-22	0	16	15	7	-15	0	15	15	7	10	25	40	40	32
0+820	3	14	12	17	11	3	14	12	15	11	28	39	37	40	36
0+830	1	12	11	13	11	1	12	11	13	11	26	37	36	38	36
0+840	9	13	4	-1	1	9	13	4	-1	1	34	38	29	24	26
0+850	-6	9	14	16	14	-6	9	14	15	14	19	34	39	40	39
0+860	-6	7	8	12	3	-6	7	8	12	3	19	32	33	37	28
0+87	6	11	2	10	1	6	11	2	10	1	31	36	27	35	26

0															
0+880	8	3	6	12	13	8	3	6	12	13	33	28	31	37	38
0+890	6	13	10	9	-2	6	13	10	9	-2	31	38	35	34	23
0+900	4	12	14	9	3	4	12	14	9	3	29	37	39	34	28
0+910	15	11	9	6	7	15	11	9	6	7	40	36	34	31	32
0+920	-14	2	12	13	1	-14	2	12	13	1	11	27	37	38	26
0+930	-3	13	10	13	6	-3	13	10	13	6	22	38	35	38	31
0+940	-11	-3	-17	-7	-9	9	-3	-2	-7	-9	34	22	23	18	16
0+950	4	4	-8	2	5	4	4	-8	2	5	29	29	17	27	30
0+960	-34	-23	-14	-17	-13	14	14	-8	-10	-10	39	39	17	15	15
0+970	11	7	-15	-5	2	11	7	3	-5	2	36	32	28	20	27
0+980	-5	-2	-3	17	12	-5	-2	-5	6	12	20	23	20	31	37
0+990	5	8	-5	11	13	5	8	-5	11	13	30	33	20	36	38
1+000	-2	9	0	1	1	-2	9	0	1	1	23	34	25	26	26
1+040	-17	2	0	6	4	-1	2	0	6	4	24	27	25	31	29
1+050	15	-12	-10	-2	-4	15	-12	-10	-2	-4	40	13	15	23	21
1+060	15	11	5	14	14	15	11	5	14	14	40	36	30	39	39
1+070	11	10	8	8	8	11	10	8	8	8	36	35	33	33	33
1+08	-1	2	-1	6	11	-1	2	-1	6	11	24	27	24	31	36

0															
1+090	-4	1	-5	-5	-5	-4	1	-5	-5	-5	21	26	20	20	20
1+100	8	5	2	9	10	8	5	2	9	10	33	30	27	34	35
1+110	5	3	-5	-2	-3	5	3	-5	-2	-3	30	28	20	23	22
1+120	-1	2	-3	6	7	-1	2	-3	6	7	24	27	22	31	32
1+130	-4	0	-5	4	3	-4	0	-5	4	3	21	25	20	29	28
1+140	11	8	0	0	0	11	8	0	0	0	36	33	25	25	25
1+150	10	6	-2	17	11	10	6	-2	15	11	35	31	23	40	36
1+160	0	5	-1	4	2	0	5	-1	4	2	25	30	24	29	27
1+170	12	5	-3	7	7	12	5	-3	7	7	37	30	22	32	32
1+180	1	5	2	9	16	1	5	2	9	16	26	30	27	34	41
1+190	3	10	6	6	10	3	10	6	6	10	28	35	31	31	35
1+200	0	11	2	15	5	0	11	2	15	5	25	36	27	40	30
1+210	0	3	-11	-2	-3	0	3	-11	-2	-3	25	28	14	23	22
1+220	3	-2	-5	9	16	3	-2	-5	9	15	28	23	20	34	40
1+230	14	9	-6	1	-3	14	9	-6	1	-3	39	34	19	26	22
1+240	9	3	-5	-4	-8	9	3	-5	-4	-8	34	28	20	21	17
1+250	-5	8	0	0	-7	-5	8	0	0	-7	20	33	25	25	18
1+26	4	9	-1	12	14	4	9	-1	12	14	29	34	24	37	39

0															
1+270	11	18	5	11	-1	11	15	5	11	-1	36	40	30	36	24
1+280	1	7	-3	10	9	1	7	-3	10	9	26	32	22	35	34
1+290	14	14	4	9	6	14	14	4	9	6	39	39	29	34	31
1+300	10	11	-2	7	8	10	11	-2	7	8	35	36	23	32	33
1+310	8	15	6	11	8	8	15	6	11	8	33	40	31	36	33
1+320	17	17	11	18	8	15	15	11	15	8	40	40	36	40	33
1+330	2	3	-3	12	14	2	3	-3	12	14	27	28	22	37	39
1+340	12	15	10	12	1	12	15	10	12	1	37	40	35	37	26
1+350	-2	11	14	15	2	-2	11	14	15	2	23	36	39	40	27
1+360	-1	4	2	8	-11	-1	4	2	8	-11	24	29	27	33	14
1+370	9	9	0	13	3	9	9	0	13	3	34	34	25	38	28
1+380	-6	2	4	6	-6	-6	2	4	6	-6	19	27	29	31	19
1+390	-5	4	11	10	-4	-5	4	11	10	-4	20	29	36	35	21

WGA - 406 (Rathasala Heneegama road)

ABC Top level sheet (Rural road in Gampaha District - Western province- package - 1)			
WGA - 406 (Rathasala Heneegama road)			
	Before Correction (mm)	**After correction (mm)**	**Projected asphalt concrete layer thickness (25 mm) (mm)**

Chainage	LHS	CL	RHS	LHS	CL	RHS	LHS	CL	RHS
0+120	34	-1	18	1	-1	-4	26	24	21
0+130	22	18	3	15	15	3	40	40	28
0+140	2	5	-3	2	5	-3	27	30	22
0+150	14	11	9	14	11	9	39	36	34
0+160	-8	-9	-16	-8	-9	-15	17	16	10
0+170	8	1	6	8	1	6	33	26	31
0+180	-20	-20	-9	-6	4	-9	19	29	16
0+190	1	-4	-29	1	-4	-8	26	21	17
0+200	-5	-10	4	-5	-10	4	20	15	29
0+210	13	6	7	13	6	7	38	31	32
0+220	15	17	-7	15	15	-7	40	40	18
0+230	0	1	-2	0	1	-2	25	26	23
0+240	-6	3	8	-6	3	8	19	28	33
0+250	-4	1	4	-4	1	4	21	26	29
0+260	15	-1	-6	15	-1	-6	40	24	19
0+270	13	14	16	13	14	15	38	39	40
0+280	5	7	3	5	7	3	30	32	28
0+290	-4	-8	-7	-4	-8	-7	21	17	18
0+300	-7	3	2	-7	3	2	18	28	27
0+310	-8	2	14	-8	2	14	17	27	39
0+320	-4	-4	10	-4	-4	10	21	21	35
0+330	-7	12	10	-7	12	10	18	37	35
0+340	-3	8	8	-3	8	8	22	33	33
0+350	-10	-3	2	-10	-3	2	15	22	27
0+360	-6	-14	-8	-6	-14	-8	19	11	17
0+370	-11	4	16	-11	4	15	14	29	40

0+380	2	8	8	2	8	8	27	33	33
0+390	-9	-10	0	-9	-10	0	16	15	25
0+400	-10	8	13	-10	8	13	15	33	38
0+410	-11	0	9	-11	0	9	14	25	34
0+420	-12	2	-3	-12	2	-3	13	27	22
0+430	-8	-2	7	-8	-2	7	17	23	32
0+440	-13	-9	-6	-13	-9	-6	12	16	19
0+450	19	24	74	14	-1	8	39	24	33
0+460	1	0	2	1	0	2	26	25	27
0+470	-9	-6	0	-9	-6	0	16	19	25
0+480	-1	-2	-20	-1	-2	-15	24	23	10
0+490	-10	15	7	-10	15	7	15	40	32
0+500	8	9	6	8	9	6	33	34	31
0+510	-6	1	-1	-6	1	-1	19	26	24
0+520	-12	-6	-4	-12	-6	-4	13	19	21
0+530	2	7	-8	2	7	-8	27	32	17
0+540	-2	-3	-5	-2	-3	-5	23	22	20
0+550	-8	3	4	-8	3	4	17	28	29
0+560	-12	-10	-1	-12	-10	-1	13	15	24
0+570	-5	-8	-11	-5	-8	-11	20	17	14
0+580	-7	-2	5	-7	-2	5	18	23	30
0+590	-6	5	1	-6	5	1	19	30	26
0+600	-7	-13	-7	-7	-13	-7	18	12	18
0+610	0	7	-7	0	7	-7	25	32	18
0+620	7	4	3	7	4	3	32	29	28
0+630	-7	13	8	-7	13	8	18	38	33
0+640	-11	9	-9	-11	9	-9	14	34	16
0+650	6	-1	4	6	-1	4	31	24	29

0+660	3	11	11	3	11	11	28	36	36
0+670	3	-7	-10	3	-7	-10	28	18	15
0+680	-2	1	6	-2	1	6	23	26	31
0+690	9	9	13	9	9	13	34	34	38
0+700	15	5	-7	15	5	-7	40	30	18
0+710	3	-6	-3	3	-6	-3	28	19	22
0+720	21	13	-20	15	13	-15	40	38	10
0+730	13	16	9	13	15	9	38	40	34
0+740	-5	5	-8	-5	5	-8	20	30	17
0+750	18	10	-2	15	10	-2	40	35	23
0+760	-16	-16	-9	-3	-15	-9	22	10	16
0+770	-9	-5	-1	-9	-5	-1	16	20	24
0+780	1	-2	1	1	-2	1	26	23	26
0+790	12	6	-9	12	6	-9	37	31	16
0+800	-12	1	-2	-12	1	-2	13	26	23
0+810	-7	-10	-2	-7	-10	-2	18	15	23
0+820	15	10	-17	15	10	-15	40	35	10
0+830	23	3	-16	2	3	-10	27	28	15
0+840	3	-13	-8	3	-13	-8	28	12	17
0+850	-1	-3	3	-1	-3	3	24	22	28
0+860	11	-7	-7	11	-7	-7	36	18	18
0+870	-9	-11	-12	-9	-11	-12	16	14	13
0+880	-16	-2	9	-10	-2	9	15	23	34
0+890	7	4	13	7	4	13	32	29	38
0+900	3	-8	13	3	-8	13	28	17	38
0+910	-1	-16	-8	-1	-8	-8	24	17	17
0+920	-2	-11	-3	-2	-11	-3	23	14	22
0+930	-2	-8	2	-2	-8	2	23	17	27

0+940	10	-4	-10	10	-4	-10	35	21	15
0+950	-4	5	2	-4	5	2	21	30	27
0+960	10	0	-11	10	0	-11	35	25	14
0+970	-4	-3	-1	-4	-3	-1	21	22	24
0+980	-1	-9	-15	-1	-9	-15	24	16	10
0+990	2	-7	-7	2	-7	-7	27	18	18
1+000	-11	-16	-13	-11	-11	-9	14	14	16
1+010	1	15	16	1	15	-3	26	40	22
1+020	-1	-6	-15	-1	-6	-15	24	19	10
1+030	-14	-14	-10	-14	-14	-10	11	11	15
1+040	-2	-3	-1	-2	-3	-1	23	22	24
1+050	3	1	14	3	1	14	28	26	39
1+060	-13	-8	-6	-13	-8	-6	12	17	19
1+070	-13	-2	-7	-13	-2	-7	12	23	18
1+080	21	7	10	9	7	10	34	32	35
1+090	28	15	1	10	15	1	35	40	26
1+100	7	-3	-2	7	-3	-2	32	22	23
1+110	16	10	-2	15	10	-2	40	35	23
1+120	13	8	3	13	8	3	38	33	28
1+130	32	-1	-14	8	-1	-14	33	24	11
1+140	-8	-2	-12	-8	-2	-12	17	23	13
1+150	-35	7	57	-15	7	11	10	32	36
1+160	8	14	7	8	14	7	33	39	32
1+170	10	14	24	10	14	15	35	39	40

WGA - 049 (Rathupaswala Henegama road)

ABC Top levevl sheet (Rural road in Gampaha District - Western province- package - 1)

WGA - 049 (Rathupaswala Henegama road)									
	Before Correction (mm)			After correction (mm)			Projected asphalt concrete layer thickness (25 mm) (mm)		
Chainage	LHS	CL	RHS	LHS	CL	RHS	LHS	CL	RHS
0+000									
0+010	0	3	-5	0	3	-5	25	28	20
0+020	6	0	8	6	0	8	31	25	33
0+030	-5	0	6	-5	0	6	20	25	31
0+040	-10	-10	-19	-10	-10	7	15	15	32
0+050	-28	-24	-28	-13	-8	7	12	17	32
0+060	10	2	-11	10	2	-11	35	27	14
0+070	13	-11	-9	13	-11	-9	38	14	16
0+080	4	2	6	4	2	6	29	27	31
0+090	-8	-8	-3	-8	-8	-3	17	17	22
0+100	-3	-9	-8	-3	-9	-8	22	16	17
0+110	-23	-11	-1	-4	-11	-1	21	14	24
0+120	-5	8	17	-5	8	13	20	33	38
0+130	-8	-12	8	-8	-12	8	17	13	33
0+150	0	-3	-5	0	-3	-5	25	22	20
0+160	-12	-5	1	-12	-5	1	13	20	26
0+170	-5	-12	5	-5	-12	5	20	13	30
0+180	-21	-14	0	2	-14	0	27	11	25
0+190	10	-3	5	10	-3	5	35	22	30
0+200	-17	-11	13	-4	-11	13	21	14	38
0+210	-1	-5	-8	-1	-5	-8	24	20	17
0+220	27	31	37	4	4	5	29	29	30
0+230	-12	-10	0	-12	-10	0	13	15	25
0+240	-20	-20	-16	11	-2	-4	36	23	21

0+250	-16	-5	1	-15	-5	1	10	20	26
0+260	-8	-9	14	-8	-9	14	17	16	39
0+270	-9	-5	6	-9	-5	6	16	20	31
0+280	-14	-15	-17	1	2	8	26	27	33
0+290	-4	-15	-10	-4	-8	-10	21	17	15
0+300	-31	-15	0	8	-9	2	33	16	27
0+310	11	-1	10	11	-1	10	36	24	35
0+320	6	7	24	6	9	10	31	34	35
0+330	1	11	12	1	11	12	26	36	37
0+340	-5	4	8	-5	4	8	20	29	33
0+350	0	8	0	0	8	0	25	33	25
0+360	0	8	7	0	8	7	25	33	32
0+370	1	2	8	1	2	8	26	27	33
0+380	6	11	3	6	11	3	31	36	28
0+390	14	5	-4	14	5	-4	39	30	21
0+400	-1	3	2	-1	3	2	24	28	27
0+410	-5	4	14	-5	4	14	20	29	39
0+420	0	9	-3	0	9	-3	25	34	22
0+430	-9	-4	-3	-9	-4	-3	16	21	22
0+440	2	12	7	2	12	7	27	37	32
0+450	-7	5	14	-7	5	14	18	30	39
0+460	-6	4	11	-6	4	11	19	29	36
0+470	-13	2	7	-13	2	7	12	27	32
0+480	3	10	2	3	10	2	28	35	27
0+490	0	10	17	0	10	15	25	35	40
0+500	2	13	13	2	13	13	27	38	38
0+510	-2	-2	-4	-2	-2	-4	23	23	21

0+520	4	2	-5	4	2	-5	29	27	20
0+530	7	10	6	7	10	6	32	35	31
0+540	6	10	-1	6	10	-1	31	35	24
0+550	5	0	3	5	0	3	30	25	28
0+560	8	11	13	8	11	13	33	36	38
0+570	10	4	9	10	4	9	35	29	34
0+580	-9	-6	7	-9	-6	7	16	19	32
0+590	-9	-9	-9	-9	-9	-9	16	16	16
0+600	12	13	9	12	13	9	37	38	34
0+610	3	1	6	3	1	6	28	26	31
0+620	9	4	6	9	4	6	34	29	31
0+630	3	4	1	3	4	1	28	29	26
0+640	-8	-6	-2	-8	-6	-2	17	19	23
0+650	-1	-5	-3	-1	-5	-3	24	20	22
0+660	2	2	8	2	2	8	27	27	33
0+670	14	8	10	14	8	10	39	33	35
0+680	15	13	13	15	13	13	40	38	38
0+690	8	8	4	8	8	4	33	33	29
0+700	9	-9	-3	9	-9	-3	34	16	22
0+710	12	15	10	12	15	10	37	40	35
0+720	6	-9	-3	6	-9	-3	31	16	22
0+730	5	-8	-1	5	-8	-1	30	17	24
0+740	-1	-9	0	-1	-9	0	24	16	25
0+750	-9	-5	3	-9	-5	3	16	20	28
0+760	-9	-9	-6	-9	-9	-6	16	16	19
0+770	-9	-6	-2	-9	-6	-2	16	19	23
0+780	-9	-9	-9	-9	-9	-9	16	16	16

0+790	-7	-9	-9	-7	-9	-9	18	16	16
0+800	13	9	-7	13	9	-7	38	34	18
0+810	14	-6	-5	14	-6	-5	39	19	20
0+820	2	7	4	2	7	4	27	32	29
0+830	1	-1	15	1	-1	15	26	24	40
0+840	-4	4	7	-4	4	7	21	29	32
0+850	-8	2	3	-8	2	3	17	27	28
0+860	-8	-2	5	-8	-2	5	17	23	30
0+870	3	-5	3	3	-5	3	28	20	28
0+880	-2	1	-1	-2	1	-1	23	26	24
0+890	14	14	2	14	14	2	39	39	27
0+900	8	5	7	8	5	7	33	30	32
0+910	15	-1	3	15	-1	3	40	24	28
0+920	-5	-10	1	-5	-10	1	20	15	26
0+930	-9	8	1	-9	8	1	16	33	26
0+940	4	0	8	4	0	8	29	25	33
0+950	7	6	11	7	6	11	32	31	36
0+960	-3	-4	3	-3	-4	3	22	21	28
0+970	2	4	9	2	4	9	27	29	34
0+980	15	4	12	15	4	12	40	29	37
0+990	-3	0	-3	-3	0	-3	22	25	22

WCO - 120

ABC Top levevl sheet (Colombo District - Western province- package - 1)				
WCO - 120				
	Before Correction	**After correction (mm)**	**Projected asphalt concrete layer thickness (25 mm) (mm)**	

	(mm)								
Chainage	LHS	CL	RHS	LHS	CL	RHS	LHS	CL	RHS
0+020	-3	9	-7	-3	9	-7	22	34	18
0+030	10	6	5	10	6	5	35	31	30
0+040	13	10	23	13	10	14	38	35	39
0+050	3	-5	16	3	-5	15	28	20	40
0+060	17	5	12	14	5	12	39	30	37
0+070	-2	18	-8	-2	8	-8	23	33	17
0+080	17	-5	-2	11	-5	-2	36	20	23
0+090	11	-1	-11	11	-1	-10	36	24	15
0+100	-10	-2	0	-10	-2	0	15	23	25
0+110	-9	-10	5	-9	-10	5	16	15	30
0+120	-25	9	-7	-11	9	-7	14	34	18
0+130	-2	-1	-17	-2	-1	-11	23	24	14
0+140	-8	-1	-16	-8	-1	-9	17	24	16
0+150	4	-2	-4	4	-2	-4	29	23	21
0+160	-10	-12	-10	-10	-12	-10	15	13	15
0+170	-2	14	-12	-2	14	-6	23	39	19
0+180	-7	-8	-4	-7	-8	-4	18	17	21
0+190	-13	-28	-19	7	7	8	32	32	33
0+200	5	7	5	5	7	5	30	32	30
0+210	13	-5	1	13	-5	1	38	20	26
0+220	14	9	27	9	9	15	34	34	40
0+230	-2	8	16	-2	8	15	23	33	40
0+240	-6	-20	7	-6	1	7	19	26	32
0+250	-2	-8	-9	-2	-8	-9	23	17	16
0+260	-6	-31	-3	-6	-5	-3	19	20	22

0+270	-12	-4	-6	-10	-4	-6	15	21	19
0+280	8	13	10	8	13	10	33	38	35
0+290	2	5	-9	2	5	-9	27	30	16
0+300	9	18	1	9	15	7	34	40	32
0+310	-7	-1	-5	-7	-1	-5	18	24	20
0+320	-7	-6	-10	-7	-6	-10	18	19	15
0+330	8	6	-3	8	6	-3	33	31	22
0+340	-15	-5	6	-5	-5	6	20	20	31
0+350	-9	1	-10	-9	1	-10	16	26	15
0+360	13	-13	-7	13	-7	-7	38	18	18
0+370	4	8	-5	4	8	-5	29	33	20
0+380	-15	-11	6	-5	2	-5	20	27	20
0+390	8	-10	-1	8	-10	-1	33	15	24
0+400	3	-3	-4	3	-3	-4	28	22	21
0+410	4	-17	18	4	-8	6	29	17	31
0+420	-4	-7	-5	-4	-7	-5	21	18	20
0+430	-2	-11	5	-2	-5	5	23	20	30
0+440	-3	7	12	-3	7	12	22	32	37
0+450	3	5	16	3	5	15	28	30	40
0+460	15	15	11	15	15	11	40	40	36
0+470	15	-4	-10	15	-4	-10	40	21	15
0+480	8	-10	-10	8	-10	-10	33	15	15
0+490	7	-2	14	7	-2	14	32	23	39
0+500	6	12	15	6	12	15	31	37	40
0+510	-10	-10	-8	-10	-10	-8	15	15	17
0+520	10	-10	-4	10	-10	-4	35	15	21
0+530	11	2	11	11	2	11	36	27	36

0+540	6	13	15	6	13	15	31	38	40
0+550	11	-8	-10	11	-8	-10	36	17	15
0+560	-10	14	14	-10	14	14	15	39	39
0+570	12	13	-10	12	13	-10	37	38	15
0+580	2	12	11	2	12	11	27	37	36
0+590	-6	13	-4	-6	13	-4	19	38	21
0+600	-2	16	18	-2	15	10	23	40	35
0+610	-7	9	-5	-7	9	-5	18	34	20
0+620	10	16	26	10	15	8	35	40	33
0+630	1	32	23	1	10	5	26	35	30
0+640	-17	17	7	-10	5	1	15	30	26
0+650	-19	15	13	-5	15	13	20	40	38
0+660	23	23	0	9	10	0	34	35	25
0+670	15	21	9	15	10	9	40	35	34
0+680	28	23	-1	10	8	-1	35	33	24
0+690	12	11	-9	12	11	-9	37	36	16
0+700	34	23	13	-10	15	13	15	40	38
0+710	-15	14	12	-4	-10	12	21	15	37
0+720	-19	-14	-16	-8	-1	-3	17	24	22
0+730	-26	-4	-27	-10	-4	-8	15	21	17
0+740	-1	7	-5	-1	7	-5	24	32	20
0+750	15	21	11	15	12	11	40	37	36
0+760	12	13	-3	12	13	-3	37	38	22
0+770	6	15	-13	6	15	-10	31	40	15
0+780	18	15	9	10	15	9	35	40	34
0+790	21	-11	-1	10	2	0	35	27	25
0+800	18	-20	-17	8	-5	-2	33	20	23

0+810	-1	-16	-21	-1	-5	-9	24	20	16
0+820	32	14	11	8	14	11	33	39	36
0+830	5	-8	-18	5	-8	-8	30	17	17
0+840	-2	0	-4	-2	0	-4	23	25	21
0+850	-10	12	-14	-10	12	-5	15	37	20
0+860	1	21	-3	1	10	-3	26	35	22
0+870	13	32	7	13	8	7	38	33	32
0+880	12	18	6	12	8	6	37	33	31
0+890	15	17	1	15	4	1	40	29	26
0+900	0	7	13	0	7	13	25	32	38
0+910	10	10	2	10	10	2	35	35	27
0+920	1	14	8	1	14	8	26	39	33
0+930	5	-5	-4	5	-5	-4	30	20	21
0+940	10	4	6	10	4	6	35	29	31
0+950	-1	5	-25	-1	5	-10	24	30	15
0+960	11	11	16	11	11	15	36	36	40
0+970	8	-1	-3	8	-1	-3	33	24	22
0+980	-4	4	13	-4	4	13	21	29	38
0+990	2	7	2	2	7	2	27	32	27
1+000	-8	0	2	-8	0	2	17	25	27
1+010	11	-10	-2	11	-10	-2	36	15	23
1+020	-6	-3	21	-6	-3	15	19	22	40
1+030	-7	5	10	-7	5	10	18	30	35
1+040	10	10	14	10	10	14	35	35	39
1+050	0	11	-1	0	11	-1	25	36	24
1+060	1	10	5	1	10	5	26	35	30
1+070	-5	18	15	-5	15	15	20	40	40

1+080	35	5	10	10	5	10	35	30	35
1+090	26	20	23	11	12	15	36	37	40
1+100	2	1	13	2	1	13	27	26	38
1+110	0	3	10	0	3	10	25	28	35

WCO - 263

ABC Top levevl sheet (Colombo District - Western province- package - 1)									
WCO - 263									
	Before Correction (mm)			**After correction (mm)**			**Projected asphalt concrete layer thickness (25 mm) (mm)**		
Chainage	**CL**	**LHS**	**RHS**	**CL**	**LHS**	**RHS**	**CL**	**LHS**	**RHS**
1+750	28	-12	-7	15	14	-7	40	39	18
1+760	-6	19	-36	-6	15	-10	19	40	15
1+770	19	14	14	-9	14	14	16	39	39
1+780	21	13	22	14	13	11	39	38	36
1+790	3	11	-1	3	11	-1	28	36	24
1+800	15	19	17	15	3	15	40	28	40
1+810	11	15	-7	11	15	-7	36	40	18
1+820	5	-8	7	5	-8	7	30	17	32
1+830	13	5	3	13	5	3	38	30	28
1+840	-48	-37	-55	15	14	11	40	39	36
1+850	3	23	-4	3	1	-4	28	26	21
1+860	23	28	20	11	15	2	36	40	27
1+870	11	10	14	11	10	14	36	35	39
1+880	2	2	10	2	2	10	27	27	35
1+890	13	12	1	13	12	1	38	37	26

1+900	5	-20	-2	5	-12	-2	30	13	23
1+910	19	1	-10	1	1	-10	26	26	15
1+920	13	8	11	13	8	11	38	33	36
1+930	12	-3	-9	12	-3	-9	37	22	16
1+940	19	4	1	7	4	1	32	29	26
1+950	10	5	0	10	5	0	35	30	25
1+960	3	-3	-5	3	-3	-5	28	22	20
1+970	3	-1	-7	3	-1	-7	28	24	18
1+980	4	-21	15	4	6	15	29	31	40
1+990	18	11	0	11	11	0	36	36	25
2+000	11	-17	3	11	-8	3	36	17	28
2+010	13	5	12	13	5	12	38	30	37
2+020	1	-5	8	1	-5	8	26	20	33
2+030	7	-5	1	7	-5	1	32	20	26
2+040	-1	0	-3	-1	0	-3	24	25	22
2+050	18	4	6	15	4	6	40	29	31
2+060	0	1	4	0	1	4	25	26	29
2+070	15	-3	20	15	-3	8	40	22	33
2+080	12	2	0	12	2	0	37	27	25
2+090	13	-7	-7	13	-7	-7	38	18	18
2+100	9	-2	12	9	-2	12	34	23	37
2+110	19	2	-1	-7	2	-1	18	27	24
2+120	5	-23	-11	5	-10	-11	30	15	14
2+130	9	10	14	9	10	14	34	35	39
2+140	1	-20	-12	1	-4	-11	26	21	14
2+150	9	14	2	9	14	2	34	39	27
2+160	-3	16	2	-3	15	2	22	40	27

2+170	4	-16	3	4	-11	3	29	14	28
2+180	-21	-22	1	-10	-11	1	15	14	26
2+190	-4	6	-6	-4	6	-6	21	31	19
2+200	6	-5	9	6	-5	9	31	20	34
2+210	1	11	0	1	11	0	26	36	25
2+220	6	1	-10	2	1	-10	27	26	15
2+230	2	7	-11	-4	7	-11	21	32	14
2+240	2	-13	-13	-4	-11	-6	21	14	19
2+250	4	-6	5	4	-6	5	29	19	30
2+260	4	0	-1	4	0	-1	29	25	24
2+270	6	-7	-2	6	-7	-2	31	18	23
2+280	-2	1	7	-2	1	7	23	26	32
2+290	11	-40	11	11	-6	11	36	19	36
2+300	8	7	3	8	7	3	33	32	28
2+310	-6	5	2	-6	5	2	19	30	27
2+320	9	8	0	9	8	0	34	33	25
2+330	10	14	14	10	14	14	35	39	39
2+340	-1	11	4	-1	11	4	24	36	29
2+350	-1	11	-13	-7	11	13	18	36	38
2+360	-8	16	-13	-8	14	-10	17	39	15
2+370	5	10	-10	5	10	-10	30	35	15
2+380	4	-10	-13	4	-10	-8	29	15	17
2+390	-7	2	-6	-7	2	-6	18	27	19
2+400	0	-24	-3	0	-10	-3	25	15	22
2+410	-1	1	7	-1	1	7	24	26	32
2+420	10	4	-2	10	4	-2	35	29	23
2+430	8	17	-1	8	15	-1	33	40	24

2+440	29	25	-9	14	15	-9	39	40	16
2+450	13	-4	14	13	-4	14	38	21	39
2+460	11	10	19	11	10	15	36	35	40
2+470	28	15	12	14	15	12	39	40	37
2+480	-6	-15	-13	-6	-11	-11	19	14	14
2+490	14	23	15	14	15	15	39	40	40
2+500	15	1	-1	15	1	-1	40	26	24
2+510	-1	-4	-8	-1	-4	-8	24	21	17
2+520	1	-10	9	1	-10	9	26	15	34
2+530	7	-17	-7	7	-10	-7	32	15	18
2+540	-12	2	6	-9	2	6	16	27	31
2+550	2	3	-10	2	3	-10	27	28	15
2+560	9	17	1	9	15	1	34	40	26
2+570	12	7	13	12	7	13	37	32	38
2+580	11	13	7	11	13	7	36	38	32
2+590	0	11	-5	0	11	-5	25	36	20
2+600	7	-10	6	7	-10	6	32	15	31
2+610	6	15	8	6	15	8	31	40	33
2+620	4	-2	11	4	-2	11	29	23	36
2+630	14	-8	24	14	-8	-1	39	17	24
2+640	2	8	-1	2	8	-1	27	33	24
2+650	-3	11	5	-3	11	5	22	36	30
2+660	18	13	-4	8	14	-4	33	39	21
2+670	15	14	19	15	14	-10	40	39	15
2+680	-5	-3	7	-5	-3	7	20	22	32
2+690	-13	5	-7	-11	5	-7	14	30	18
2+700	8	-7	-17	8	-7	0	33	18	25

2+710	14	-3	-12	14	-3	-12	39	22	13
2+720	9	-41	17	9	-1	15	34	24	40
2+730	14	-10	-3	14	-10	-3	39	15	22
2+740	11	0	11	11	0	11	36	25	36
2+750	15	-3	11	15	-3	11	40	22	36
2+760	-6	-4	-13	-6	-4	-11	19	21	14
2+770	16	10	0	-5	10	0	20	35	25
2+780	-3	16	0	-3	-3	0	22	22	25
2+790	8	-16	14	8	-10	14	33	15	39

WCO - 271

ABC Top levevl sheet (Colombo District - Western province- package - 1)									
WCO - 271									
	Before Correction (mm)			**After correction (mm)**			**Projected asphalt concrete layer thickness (25 mm) (mm)**		
Chainage	**CL**	**LHS**	**RHS**	**CL**	**LHS**	**RHS**	**CL**	**LHS**	**RHS**
2+770	11	4	4	11	4	4	36	29	29
2+780	23	15	22	12	10	2	37	35	27
2+790	10	11	8	10	11	8	35	36	33
2+800	-3	-16	-3	-3	-10	-3	22	15	22
2+810	-29	4	-1	5	4	-1	30	29	24
2+820	16	0	6	10	0	6	35	25	31
2+830	7	10	-9	7	10	-9	32	35	16
2+840	28	40	7	3	10	7	28	35	32
2+850	8	23	6	8	10	6	33	35	31
2+860	14	-6	4	14	-6	4	39	19	29

2+870	-10	-21	-8	-10	10	-8	15	35	17
2+880	0	-6	-1	0	-6	-1	25	19	24
2+890	0	9	-12	0	9	-12	25	34	13
2+900	-3	-2	-4	-3	-2	-4	22	23	21
2+910	3	3	-4	3	3	-4	28	28	21
2+920	-3	3	11	-3	3	11	22	28	36
2+930	14	-12	16	14	-7	7	39	18	32
2+940	-2	14	-2	-2	14	-2	23	39	23
2+950	-23	5	-31	3	5	10	28	30	35
2+960	-2	2	-8	-2	2	-8	23	27	17
2+970	25	12	-7	15	12	-7	40	37	18
2+980	14	16	-2	14	6	-2	39	31	23
2+990	18	-7	10	6	-7	10	31	18	35
3+000	-3	4	-8	-3	4	-8	22	29	17
3+010	-9	-30	-2	-9	-9	-2	16	16	23
3+020	-14	8	-12	-10	-10	-12	15	15	13
3+030	22	4	-9	-4	4	-9	21	29	16
3+040	-2	2	-8	-2	2	-8	23	27	17
3+050	-7	-5	17	-7	-5	2	18	20	27
3+060	16	29	0	9	-6	0	34	19	25
3+070	0	-5	-1	0	-5	-1	25	20	24
3+080	-1	-2	-1	-1	-2	-1	24	23	24
3+090	-22	-19	-18	-2	-6	-3	23	19	22
3+100	0	8	6	0	8	6	25	33	31
3+110	10	12	9	10	12	9	35	37	34
3+120	-10	5	-42	-10	5	-9	15	30	16
3+130	0	-9	29	-10	5	11	15	30	36

3+140	-12	-18	-13	-9	-8	9	16	17	34
3+150	6	11	25	6	11	10	31	36	35
3+160	-7	-13	2	-7	-10	2	18	15	27
3+170	-5	-7	-4	-5	-7	-4	20	18	21
3+180	-4	7	-6	-4	7	-6	21	32	19
3+190	-11	5	10	-4	5	10	21	30	35
3+200	3	3	-10	3	3	-10	28	28	15
3+210	-24	18	56	10	9	8	35	34	33
3+220	13	26	-12	13	14	-10	38	39	15
3+230	11	8	2	11	8	2	36	33	27
3+240	-7	0	-12	-7	0	-5	18	25	20
3+250	-15	-5	0	-15	-10	0	10	15	25
3+260	-7	0	-4	-7	0	-4	18	25	21
3+270	-4	7	-4	-4	7	-4	21	32	21
3+280	-8	-5	16	-8	-5	15	17	20	40
3+290	14	21	17	14	7	4	39	32	29
3+300	14	24	19	14	10	15	39	35	40
3+310	14	27	17	14	12	15	39	37	40
3+320	14	27	17	14	15	15	39	40	40
3+330	10	11	-1	10	11	-1	35	36	24
3+340	-12	0	-32	-12	0	15	13	25	40
3+350	-1	2	-7	-1	2	-7	24	27	18
3+360	7	21	25	7	10	10	32	35	35
3+370	7	7	-13	7	7	-5	32	32	20
3+380	15	33	-6	15	11	-6	40	36	19
3+390	13	34	-8	13	15	-8	38	40	17
3+400	-1	9	-6	-1	9	-6	24	34	19

3+410	-24	5	5	11	5	5	36	30	30
3+420	3	12	5	3	12	5	28	37	30
3+430	13	17	3	13	15	3	38	40	28
3+440	-9	-26	5	-9	8	5	16	33	30
3+450	-8	-8	2	-8	-8	2	17	17	27
3+460	-6	-6	-10	-6	-6	-10	19	19	15
3+470	-8	8	2	-8	8	2	17	33	27
3+480	-19	-32	-17	5	-7	10	30	18	35
3+490	-4	-2	1	-4	-2	1	21	23	26
3+500	5	7	-1	5	7	-1	30	32	24
3+510	4	4	-6	4	4	-6	29	29	19
3+520	3	0	14	3	0	14	28	25	39
3+530	5	8	9	5	8	9	30	33	34
3+540	-23	0	-8	10	0	-8	35	25	17
3+550	-15	5	-14	2	5	-3	27	30	22
3+560	-7	6	3	-7	6	3	18	31	28
3+570	-8	4	-4	-8	4	-4	17	29	21
3+580	16	5	21	15	5	-9	40	30	16
3+590	30	1	42	9	1	12	34	26	37
3+600	12	22	22	12	8	8	37	33	33
3+610	-8	17	8	-8	-3	8	17	22	33
3+620	-18	3	-27	-10	3	1	15	28	26
3+630	15	-6	-9	15	-6	-9	40	19	16
3+640	-9	-9	-7	-9	-9	-7	16	16	18
3+650	-1	11	25	-1	11	0	24	36	25
3+660	20	19	32	13	15	10	38	40	35
3+670	-11	9	27	-11	9	15	14	34	40

3+680	-8	11	9	-8	11	9	17	36	34
3+690	0	11	14	0	11	14	25	36	39
3+700	-3	6	10	-3	6	10	22	31	35
3+710	1	12	3	1	12	3	26	37	28
3+720	9	15	-4	9	15	-4	34	40	21
3+730	17	17	27	15	15	15	40	40	40
3+740	5	8	22	5	8	15	30	33	40
3+750	21	-11	25	10	-11	15	35	14	40
3+760	11	6	-3	11	6	-3	36	31	22
3+770	13	7	3	13	7	3	38	32	28
3+780	12	-16	22	12	-12	15	37	13	40
3+790	8	-38	18	8	0	15	33	25	40
3+800	2	0	13	2	0	13	27	25	38

EBT -007

ABC Top levevl sheet (Batticaloa District - Eastern province- package - 3)									
EBT -007									
	Before Correction (mm)			**After correction (mm)**			**Projected asphalt concrete layer thickness (25 mm) (mm)**		
Chainage	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**
1+890	8	-2	13	8	-2	13	33	23	38
1+900	11	8	-7	11	8	-7	36	33	18
1+910	-3	2	-1	-3	2	-1	22	27	24
1+920	-3	-6	7	-3	-6	7	22	19	32
1+930	5	10	2	5	10	2	30	35	27
1+940	2	-3	6	2	-3	6	27	22	31

1+950	1	-9	-8	1	-9	-8	26	16	17
1+960	-5	7	8	-5	7	8	20	32	33
1+970	-10	-1	8	-10	-1	8	15	24	33
1+980	0	5	20	0	5	10	25	30	35
1+990	4	-6	-3	4	-6	-3	29	19	22
2+000	0	-3	3	0	-3	3	25	22	28
2+010	4	8	1	4	8	1	29	33	26
2+020	2	-7	-4	2	-7	-4	27	18	21
2+030	6	-5	1	6	-5	1	31	20	26
2+040	8	-2	8	8	-2	8	33	23	33
2+050	-14	2	-14	-7	2	-2	18	27	23
2+060	-7	8	-8	-7	8	-8	18	33	17
2+070	-3	-4	-4	-3	-4	-4	22	21	21
2+080	-2	0	-4	-2	0	-4	23	25	21
2+090	-5	-2	-5	-5	-2	-5	20	23	20
2+100	-4	-4	5	-4	-4	5	21	21	30
2+110	-2	-3	-3	-2	-3	-3	23	22	22
2+120	1	10	14	1	10	14	26	35	39
2+130	9	4	0	9	4	0	34	29	25
2+140	-7	-1	0	-7	-1	0	18	24	25
2+150	-4	1	-24	-4	1	-9	21	26	16
2+160	-7	1	-6	-7	1	-6	18	26	19
2+170	10	-6	-9	10	-6	-9	35	19	16
2+180	-7	-14	-8	-7	-4	-8	18	21	17
2+190	-16	-13	-11	-9	-3	-7	16	22	18
2+200	-13	-18	-11	-6	-2	-5	19	23	20
2+210	-6	-12	-18	-6	-5	-1	19	20	24
2+220	-9	-9	-7	-9	-9	-7	16	16	18

2+230	-16	-17	-20	5	-5	-3	30	20	22
2+240	-17	-12	-22	-8	1	-4	17	26	21
2+250	-19	-3	2	-9	-3	2	16	22	27
2+260	1	-4	0	1	-4	0	26	21	25
2+270	-15	-11	-7	-9	-10	-7	16	15	18
2+280	-21	-9	-16	-1	-9	-4	24	16	21
2+290	5	-16	-8	5	-5	-8	30	20	17
2+300	-11	-9	-18	-9	-9	-6	16	16	19
2+310	-22	-4	2	-3	-4	2	22	21	27
2+320	-16	-10	-24	-5	-10	9	20	15	34
2+330	-9	-20	-13	-9	-3	-8	16	22	17
2+340	-9	-22	-8	-9	-5	-8	16	20	17
2+350	-11	-25	-2	-10	-4	-8	15	21	17
2+360	-13	-10	-9	-6	-10	-9	19	15	16
2+370	-16	-22	-7	-10	-5	-3	15	20	22
2+380	-6	13	0	-6	13	0	19	38	25
2+390	8	13	14	8	13	14	33	38	39
2+400	1	10	14	1	10	14	26	35	39
2+410	0	7	1	0	7	1	25	32	26
2+420	13	13	13	13	13	13	38	38	38
2+430	-9	11	13	-9	11	13	16	36	38
2+440	-5	0	25	-5	0	10	20	25	35
2+450	9	0	9	9	0	9	34	25	34
2+460	22	2	5	8	2	5	33	27	30
2+470	3	5	6	3	5	6	28	30	31
2+480	-3	9	3	-3	9	3	22	34	28
2+490	23	7	8	15	7	8	40	32	33
2+500	1	8	3	1	8	3	26	33	28

2+510	13	14	-4	13	14	-4	38	39	21
2+520	10	-2	10	10	-2	10	35	23	35
2+530	1	14	2	1	14	2	26	39	27
2+540	14	15	12	14	15	12	39	40	37
2+550	12	25	-4	12	7	-4	37	32	21
2+560	9	8	10	9	8	10	34	33	35
2+570	7	10	8	7	10	8	32	35	33
2+580	11	13	0	11	13	0	36	38	25
2+590	-2	13	13	-2	13	13	23	38	38
2+600	1	6	6	1	6	6	26	31	31
2+610	-3	4	15	-3	4	15	22	29	40
2+620	-4	4	6	-4	4	6	21	29	31
2+630	10	-5	1	10	-5	1	35	20	26
2+640	7	6	10	7	6	10	32	31	35
2+650	23	8	23	11	8	12	36	33	37
2+660	15	9	15	15	9	15	40	34	40
2+670	10	2	10	10	2	10	35	27	35
2+680	6	-1	13	6	-1	13	31	24	38
2+690	14	-5	14	14	-5	14	39	20	39
2+700	1	6	1	1	6	1	26	31	26
2+710	11	-9	11	11	-9	11	36	16	36
2+750	9	7	18	9	7	4	34	32	29
2+760	7	-5	2	7	-5	2	32	20	27
2+770	9	10	19	9	10	6	34	35	31
2+780	10	9	4	10	9	4	35	34	29
2+790	8	-2	13	8	-2	13	33	23	38
2+800	25	-6	4	14	-6	4	39	19	29
2+810	4	-7	7	4	-7	7	29	18	32

2+820	-3	20	5	-3	3	5	22	28	30
2+830	-3	12	-2	-3	12	-2	22	37	23
2+840	15	15	22	15	15	6	40	40	31
2+850	4	14	19	4	14	6	29	39	31
2+860	24	14	15	15	14	15	40	39	40
2+870	5	12	10	5	12	10	30	37	35
2+880	13	8	4	13	8	4	38	33	29
2+890	24	11	19	10	11	11	35	36	36
2+900	8	21	25	8	7	0	33	32	25
2+910	24	1	25	5	1	11	30	26	36
2+920	12	8	16	2	8	0	27	33	25
2+930	25	-21	-13	10	3	-10	35	28	15
2+940	14	23	9	14	6	9	39	31	34
2+950	25	44	20	5	10	10	30	35	35
2+960	-28	19	29	10	8	10	35	33	35
2+970	23	19	25	10	2	6	35	27	31
2+980	24	13	17	8	-1	9	33	24	34
2+990	21	16	31	-2	12	-2	23	37	23
3+000	33	25	14	15	0	4	40	25	29

EBT -192

ABC Top levevl sheet (Batticaloa District - Eastern province- package - 3)									
EBT -192									
	Before Correction (mm)			**After correction (mm)**			**Projected asphalt concrete layer thickness (25 mm) (mm)**		
Chainage	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**

3+430	6	-10	-10	6	-10	-10	31	15	15
3+440	14	8	1	14	8	1	39	33	26
3+450	6	-1		6	-1		31	24	25
3+460	1	1	10	1	1	10	26	26	35
3+470	14	-1	14	14	-1	14	39	24	39
3+480	1	1	10	1	1	10	26	26	35
3+490	14	-1	14	14	-1	14	39	24	39
3+500	-4	10	11	-4	10	11	21	35	36
3+510	-5	0	12	-5	0	12	20	25	37
3+520	6	5	14	6	5	14	31	30	39
3+530	12	-8	17	12	-8	15	37	17	40
3+540	-1	-6	4	-1	-6	4	24	19	29
3+550	0	5	-10	0	5	-10	25	30	15
3+560	15	10	5	15	10	5	40	35	30
3+570	5	13	-5	5	13	-5	30	38	20
3+580	3	15	1	3	15	1	28	40	26
3+590	7	14	10	7	14	10	32	39	35
3+600	15	16	6	15	15	6	40	40	31
3+610	1	10	-3	1	10	-3	26	35	22
3+620	-2	10	10	-2	10	10	23	35	35
3+630	14	9	8	14	9	8	39	34	33
3+920	16	12	11	15	12	11	40	37	36
3+930	6	3	-2	6	3	-2	31	28	23
3+940	3	2	7	3	2	7	28	27	32
3+950	11	1	-4	11	1	-4	36	26	21
3+960	0	6	15	0	6	15	25	31	40
3+970	5	0	22	5	0	15	30	25	40
3+980	14	4	5	14	4	5	39	29	30

3+990	13	9	9	13	9	9	38	34	34
4+000	10	7	6	10	7	6	35	32	31
4+010	1	12	8	1	12	8	26	37	33
4+020	12	18	9	12	15	9	37	40	34
4+030	9	8	13	9	8	13	34	33	38
4+040	2	9	17	2	9	15	27	34	40
4+050	5	5	17	5	5	15	30	30	40
4+060	27	-13	-8	15	-10	-8	40	15	17
4+070	2	1	-8	2	1	-8	27	26	17
4+080	23	-17	31	15	-10	15	40	15	40
4+090	12	6	-1	12	6	-1	37	31	24

EBT -27

ABC Top levevl sheet (Batticaloa District - Eastern province- package - 3)									
EBT -27									
	Before Correction (mm)			After correction (mm)			Projected asphalt concrete layer thickness (25 mm) (mm)		
Chainage	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**
0+250	11	-9	31	11	-9	15	36	16	40
0+260	-3	-13	-28	-3	-10	-10	22	15	15
0+270	13	7	37	13	7	1	38	32	26
0+280	53	8	-2	10	8	-2	35	33	23
0+290	-5	-1	10	-5	-1	10	20	24	35
0+300	24	34	50	12	14	1	37	39	26
0+310	33	28	18	1	1	12	26	26	37
0+320	11	-11	1	11	-10	1	36	15	26

0+330	-11	-41	-51	-10	-10	-10	15	15	15
0+340	37	27	-3	1	1	-3	26	26	22
0+350	-14	-7	10	-10	-7	10	15	18	35
0+360	6	-29	-25	6	-10	-10	31	15	15
0+370	-31	-31	-11	-10	-10	-10	15	15	15
0+380	-25	-9	44	-10	-9	1	15	16	26
0+390	-28	-4	-49	-10	-4	-10	15	21	15
0+400	20	-40	-35	1	-10	-10	26	15	15
0+410	19	-6	-15	1	-6	-10	26	19	15
0+420	-6	4	-6	-6	4	-6	19	29	19
0+430	-6	9	-1	-6	9	-1	19	34	24
0+440	-17	-7	-7	-10	-7	-7	15	18	18
0+450	7	12	0	7	12	0	32	37	25
0+460	-18	-25	-34	-10	-10	-10	15	15	15
0+470	-42	-48	1	-10	-10	1	15	15	26
0+480	40	25	45	1	14	14	26	39	39
0+490	18	25	48	14	14	14	39	39	39
0+500	32	28	18	14	14	1	39	39	26

EBT -36

ABC Top levevl sheet (Batticaloa District - Eastern province- package - 3)									
EBT -36									
	Before Correction (mm)			**After correction (mm)**			**Projected asphalt concrete layer thickness (25 mm) (mm)**		
Chainage	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**	**LHS**	**CL**	**RHS**
0+710	2	-4	-3	2	-4	-3	27	21	22
0+720	4	10	10	4	10	10	29	35	35

0+730	2	-3	9	2	-3	9	27	22	34
0+740	-5	-8	2	-5	-8	2	20	17	27
0+750	9	-4	-5	9	-4	-5	34	21	20
0+760	24	4	-10	10	4	-10	35	29	15
0+770	1	-4	-8	1	-4	-8	26	21	17
0+780	3	4	8	3	4	8	28	29	33
0+790	4	12	3	4	12	3	29	37	28
0+800	-10	1	6	-10	1	6	15	26	31
0+810	-19	9	13	-3	9	13	22	34	38
0+820	3	8	2	3	8	2	28	33	27
0+830	15	6	11	15	6	11	40	31	36
0+840	10	5	5	10	5	5	35	30	30
0+850	1	0	-4	1	0	-4	26	25	21
0+860	-5	9	15	-5	9	15	20	34	40
0+870	9	28	3	9	5	3	34	30	28
0+880	2	2	2	2	2	2	27	27	27
0+890	9	3	9	9	3	9	34	28	34
0+900	-2	8	15	-2	8	15	23	33	40
0+910	14	15	13	14	15	13	39	40	38
0+920	8	9	10	8	9	10	33	34	35
0+930	13	15	15	13	15	15	38	40	40
0+940	14	14	15	14	14	15	39	39	40
0+950	11	10	7	11	10	7	36	35	32
0+960	11	21	10	11	6	10	36	31	35
0+970	3	13	15	3	13	15	28	38	40
0+980	14	12	6	14	12	6	39	37	31
0+990	7	10	13	7	10	13	32	35	38

1+000	6	13	13	6	13	13	31	38	38
1+010	20	9	15	5	9	15	30	34	40
1+020	22	11	9	11	11	9	36	36	34
1+030	-1	14	9	-1	14	9	24	39	34
1+040	12	13	6	12	13	6	37	38	31
1+050	10	17	8	10	10	8	35	35	33
1+060	10	1	-10	10	1	-10	35	26	15
1+070	-11	3	12	-4	3	13	21	28	38
1+080	7	5	2	7	5	2	32	30	27
1+090	-9	-5	-3	-9	-5	-3	16	20	22
1+100	-2	-2	5	-2	-2	5	23	23	30
1+110	2	1	8	2	1	8	27	26	33
1+120	-6	0	10	-6	0	10	19	25	35
1+130	-10	-3	-4	-10	-3	-4	15	22	21
1+140	1	2	22	1	2	2	26	27	27
1+150	4	8	6	4	8	6	29	33	31
1+160	4	12	5	4	12	5	29	37	30
1+170	10	21	9	10	6	9	35	31	34
1+180	12	10	10	12	10	10	37	35	35
1+190	5	7	12	5	7	12	30	32	37
1+200	-4	9	14	-4	9	14	21	34	39
1+210	0	12	4	0	12	4	25	37	29
1+220	15	-1	15	15	-1	15	40	24	40
1+230	2	-3	1	2	-3	1	27	22	26
1+240	15	11	20	15	11	9	40	36	34
1+250	21	2	-11	10	2	5	35	27	30
1+260	10	5	0	10	5	0	35	30	25

1+270	15	0	18	15	0	2	40	25	27
1+280	9	10	12	9	10	12	34	35	37
1+290	10	12	5	10	12	5	35	37	30
1+300	-9	1	4	-9	1	4	16	26	29
1+310	1	8	10	1	8	10	26	33	35
1+320	0	-5	-3	0	-5	-3	25	20	22
1+330	0	5	8	0	5	8	25	30	33
1+340	12	4	3	12	4	3	37	29	28
1+350	13	8	10	13	8	10	38	33	35
1+360	-3	-9	-3	-3	-9	-3	22	16	22
1+370	14	1	4	14	1	4	39	26	29
1+380	1	3	14	1	3	14	26	28	39
1+390	13	-4	-2	13	-4	-2	38	21	23

ANNEXURE 3:

Temperature reading of TAS asphalt heat reduction rate

Case study 1

time	8.00 am
Base temperature	23
Air temperature	25

Time (min)	Asphalt Layer temperature (ºC)											
	20 mm Layer			25 mm Layer			30 mm Layer			35 mm Layer		
1	140	137	139	139	140	140	140	140	140	140	139	139
2	128	128	128	130	130	130	131	133	138	138	137	138
3	114	116	118	122	122	122	128	130	135	136	135	137
4	107	113	112	110	120	120	125	126	130	135	132	135
8	100	103	101	97	112	111	112	115	120	127	125	127
12	88	93	90	95	98	98	102	105	106	118	115	115
16	75	79	79	85	88	88	93	98	100	108	110	110
20	70	72	72	78	82	79	87	92	95	96	102	106
24	60	65	65	72	75	75	80	86	88	88	95	96
28	55	60	60	67	70	70	75	79	79	87	88	88
32	51	56	56	60	65	63	68	74	76	84	83	83
36	50	52	52	56	59	59	63	70	70	76	78	78
40	46	47	48	52	55	55	58	60	60	70	75	76
60	37.5	37.5	37.5	43	43	43	50	50	50	65	70	70

Case Study 2

time	12.00 noon
Base temperature	52.5

Air temperature	27

Time (Min)	Asphalt concrete layer temperature (°C)											
	20 mm layer			25 mm layer			30 mm layer			35 mm layer		
1	139.2	142	140	140	139	140	138	140	141	138	138	143
2	138	138	138	138	140	140	139	139	138	137	136	143
3	133	138	138	138	138	139	138	138	138	137	136	143
4	130	136	134	137	137	137	136	136	134	136	136	142
5	128	133	130	134	135	134	137	137	137	134	135	137
6	126	128	127	131	131	132	132	132	131	131	131	136
7	126	126	123	127	130	130	130	130	131	131	131	135
8	117	124	122	121	128	129	128	128	127	130	130	134
9	116	123	121	116	127	127	125	126	124	130	130	134
12	110	118	111	112	122	119	123	125	122	128	128	132
16	102	112	100	112	119	116	120	122	120	124	123	126
20	98	107	98	112	114	114	117	119	118	123	123	125
24	92	96	93	108	112	109	115	116	114	119	120	120
28	89	95	90	104	108	107	111	113	110	118	119	119
32	87	87	87	97	104	101	108	110	107	116	116	116
36	84	85	85	94	101	100	102	106	102	111	114	114
40	84	84	84	93	99	97	100	102	99	108	112	112
73	61	63	60	70	72	72	74	72	78	77	79	79

Case study 3

time	4.00 pm
Base temperature	30.2
Air temperature	26

Time (Min)	Asphalt concrete layer temperature (°C)			
	20 mm layer	25 mm layer	30 mm layer	35 mm layer

1	140	141	140	140	140	140	140	140	140	140	140	140
2	130	130	132	132	131	130	134	134	134	136	143	136
3	127	128	127	132	131	130	132	132	132	133	133	133
4	120	124	124	129	129	124	130	130	130	131	131	131
5	117	118	119	126	126	124	127	128	127	128	129	128
6	114	109	108	121	123	120	125	126	125	126	128	126
7	110	106	107	118	117	116	120	121	120	120	122	122
8	102	104	106	112	115	112	114	116	114	116	120	119
9	99	101	97	107	111	104	109	112	114	114	118	117
10	97	97	96	106	108	103	108	111	113	113	115	113
11	92	94	94	101	105	99	106	110	106	108	112	110
12	90	91	90	100	100	96	106	105	110	108	111	110
13	87	87	87	97	99	92	103	109	103	106	112	107
14	85	85	85	93	97	87	101	98	105	106	106	106
15	84	84	82	93	94	86	99	98	102	105	105	103
16	80	82	79	89	92	86	95	98	102	104	104	97
17	75	80	76	84	89	81	95	95	100	102	103	97
18	74	77	74	83	87	81	94	93	96	100	99	96
19	72	75	72	82	85	78	90	89	94	100	96	94
20	71	74	71	78	83	77	89	89	92	97	96	93
21	69	72	67	79	82	73	87	88	92	97	96	91
22	68	70	67	76	79	72	84	87	87	97	96	91
23	67	69	66	71	78	72	81	86	84	97	93	85
24	66	68	65	71	76	70	81	82	81	95	90	85
25	63	67	64	70	74	70	80	82	83	95	88	84
26	62	66	63	68	73	70	80	81	82	90	90	80
27	59	60	60	68	72	68	79	79	80	92	86	80
28	56	60	56	66	70	66	77	77	78	89	82	80
29	55	59	55	62	68	64	76	76	76	83	80	81
30	54	58	55	61	65	61	75	75	75	83	81	78
31	52	57	53	61	65	59	74	74	74	83	82	77

32	52	57	54	61	63	59	73	74	74	81	80	77
33	52	55	53	58	63	58	72	72	73	80	77	75
34	52	54	53	58	62	56	71	72	71	78	76	73
35	51	54	52	56	61	56				77	77	72
36	51	53	52	54	59	54				79	76	72
37				54	59	54				74	75	72
38				54	58	53				74	74	71