Newly Developed Aggregate Gradation for Five Asean Countries

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Abstract. This paper presents the new aggregate gradation of the porous asphalt (PA) mixture in five Asean countries including Malaysia, Indonesia, Vietnam, Thailand and Singapore. The PA aggregate gradation need to be developed as it may suit all of the countries and the air voids content for Asean countries can be standardized. This study was carried out to investigate the air voids properties. Several aggregate testing should be conducted in order to get the new porous asphalt aggregate gradation that suits all Asean countries. Sieve analysis test was conducted to see the patterns of the aggregate gradation curve. Sieve analysis test were tested three times for each of the countries to get the best average. The results were then plotted in one graph for all countries to be evaluated. From the analysis, Singapore specification started with 0.075mm, followed by 0.15mm, 0.3mm, o.6mm and 2.36mm are seems to have all the criteria in terms of aggregate gradations for fine aggregate and the rest are from Thailand aggregate specification for lower line while for upper line, Vietnam specifications were proved to have all the criteria within all five countries gradations.

1. Introduction

Porous asphalt is an open graded that consist of low amount of fine aggregates that may lead to have higher air voids that may reduce the charge water underground[1, 2]. The reduced of fines aggregate in porous asphalt mixture tend to leave air pockets that water can drain through it[3, 4] and the asphalt binder to drain off from the mixture [5]. This pavement type can be use as storm-water management as

it allows the water to flow through the mixture [6]. Different country has different size aggregate gradation specifications as all countries have different Nominal Maximum Aggregate Size (NMAS). Several problems of asphalt mixture such as stiffness, stability, durability, permeability, workability, fatigue resistance, skid resistance and moisture sensitivity will be affected by the aggregate gradation. Thus, this make the air void contents for each of the countries might be different as most of the porous asphalt gradation has more courses aggregate compared to fine aggregate. Aggregate gradation determines the void content within the structure of aggregate and is one of the main factor that effect the characteristics of the air voids content[1, 7]. The aggregate gradation needs to be developed that may suit most of the Asian countries e.g. Singapore, Thailand, Vietnam, Indonesia and Malaysia as the climate changes almost the same. The sieve analysis is also can be called the aggregate grading as it is defined by the elemental composition of an aggregate. Aggregate that consist of particles at different sizes would provide a mass with fewer voids, thus more air voids content will be found in the compacted mass when all of an aggregate particles are in similar size. Many previous researchers focus on the study of bitumen only which highlight the needs for a new development for a new aggregate gradation in the industry as this may help reducing the cost for unnecessary grade of aggregates in the mixture. Therefore, this study is the development of the new aggregate gradation that will strengthen the bonding between the aggregates and the binder because of the course and fine aggregate are observed from all the existing aggregate gradation.

2. Materials and Methods

In this study, five types of aggregate gradation specifications were adopted from various countries i.e. Malaysia (Public Works Department) [8], Singapore specification [9], Indonesia (National Asphalt Pavement Association) [10], Vietnam and Thailand [11]. Aggregate gradation is crucially important in determine the performance of asphalt mixture [12]. The aggregate gradation is obtained from the sieve analysis test and expressed within the sort of the curve or namely as ‘s’ curve. The grading curve termed is the curve that displays the whole percentage of the aggregate that passes through the sieves delineate on the ordinate. It is together with the sieve openings to the ordered series outlined on the abscissa. It also whether is too large or deficient in a particular scale it is compatible with that defined by the grading curve for a specific sample that shows whether the grading of a given sample. The distribution of the particle size of the aggregate mass will be such that the smaller particles fill the gaps between the larger particles. The main materials that used in this study is Crushed granite aggregate from Syarikat Quary Bekelah Sdn Bhd. From the same company, two types of aggregates were supplied which are categorised into two stockpiles where stockpile A is coarse aggregate and stockpile B is fine aggregates. It has been used for laboratory sample preparation in order to develop the new aggregate gradation. The existence aggregate gradations and their specifications according to their countries used are presented in Figure 1 and Table 1. Aggregate gradation can be varying for all countries but the most strength for aggregate can be seen through its NMAS. From this graph, it is shown that Malaysia has different Nominal Maximum Aggregate Size (NMAS) from other four countries which is 14.0mm while Singapore and Thailand 13.2mm, Indonesia and Vietnam 12.5mm. These five curves will be simplified and the standard was within the sieve analysis envelope.

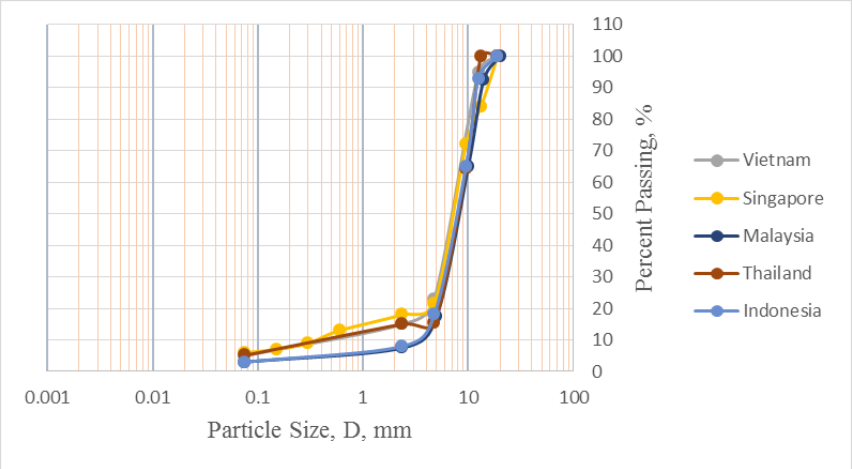

Figure 1. Aggregate gradation for porous asphalt for all five ASEAN countries

Table 1. Aggregate gradation specifications for porous asphalt for all five ASEAN countries

Sieve Size	Vietnam	Singapore	Malaysia	Thailand	Indonesia
20.0	-	-	100	-	-
19.0	100	100	-	100	100
14.0	-	-	92.5	-	-
13.2	-	84	-	100	-
12.5	95	-	-	-	93
10.0	-	-	65	-	-
9.5	-	72	-	64.2	65
5.0	-	-	17.5	-	-
4.75	23	21.5	-	15.6	18
2.36	15	18	7.5	15	8
0.60	-	5	-	-	-
0.30	-	9	-	-	-
0.15	-	7	-	-	-
0.075	5	6	3	5.1	3

2.1 Sieves Analysis Test

Sieve analysis is the process of dividing the aggregates into fraction according to their country's specification. The sieve analysis test of the porous asphalt was tested in according to the standard sieve test (ASTM D422) and aggregate blending by try and error method for three times. The process of aggregate blending can be defined as the intermixing of two or more fine and coarse aggregate to produce an improved grading or other properties with that combination. The specified target could be achieved when the aggregate blending of two or more types in order to meet the standard requirement with the job mix formula. The first try and error were 50% from stockpile A and 50% from stockpile B followed by 60% from stockpile A and 40% from stockpile B and lastly 70% from stockpile A and 30% from stockpile B. Proportions of aggregate were determined to make sure all the stockpile are within the specification envelope. This research is done in order to develop new aggregate gradation to improve the existence aggregate gradation by comparing with the other five Asean countries specifications such as Singapore, Vietnam, Thailand and Indonesia which these countries are experiencing almost the same weather and temperature. For Malaysia, it is done in accordance with JKR Standard Specification for Road works while for other countries are following their own specification for sieve analysis test. Sieve analysis test that has been done 3 times for each country using their own specifications were then plotted in graph separately.

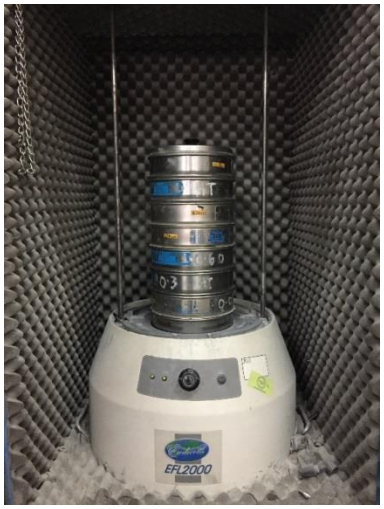

Figure 2. Mechanical Sieve Shaker and Test Sieves

3. Results and Discussions

Figure 3 shows that all 3 lines from each country from sieve analysis test are then plotted in the same graph to see the pattern. As the try and error method was conducted three times for each country, there are a total of 15 lines plotted on this graph. From this graph, it is hard to differentiate the upper and lower line. Hence, it is then calculated in average for each country and plotted in graph separately. The results from all countries were plotted in the same graph as shown in figure 4.

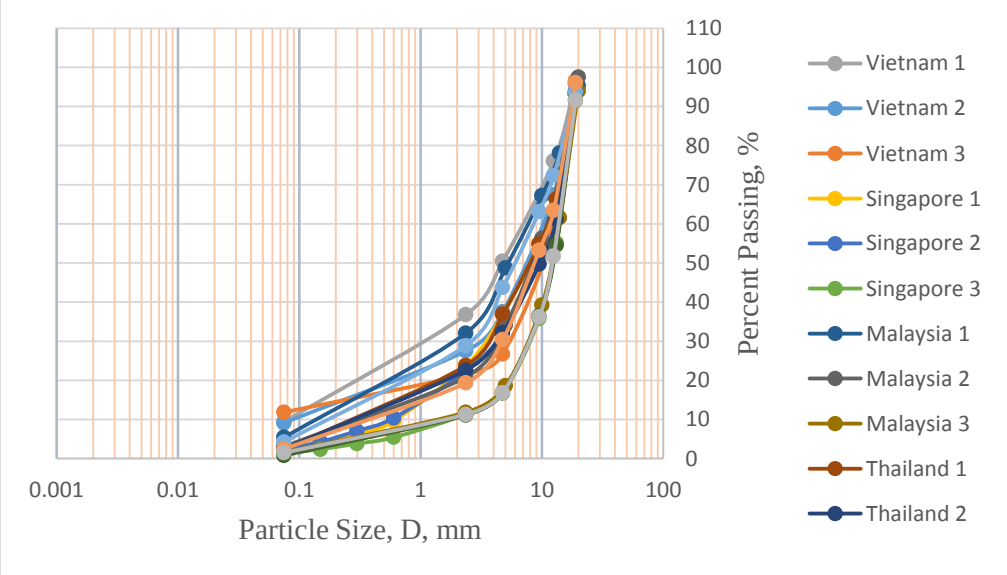

Figure 3. Aggregate Gradation Curve for all five ASEAN countries

The average values of the lower and upper line for the new aggregate gradation are shown in Table 2 and plotted in graph as in figure 4. The test has been done 3 times per country in order to get the best average. It is then calculated and was combined in the same graph to see the patterns. Figure 4 shows that only five lines which each line represent each country. From the figure 4, within all the specification from all the five countries, Vietnam shown to be the upper line that is cover overall five countries gradation that fulfill all five countries criteria in terms of aggregate gradation. For lower line, the graph shows that the fine aggregate should follow Singapore specification and the rest are from Thailand specifications as these two countries specifications are within all the five countries criteria in terms of aggregate gradation. Singapore specification for sieve size is more details as compared to

other countries for fine aggregates. This makes Singapore specifications were chosen for the lower line. The larger particles are in between may lead to more air voids due to the small particles are not enough to fill the voids. [13]. Lastly, Figure 5 shows that the upper line and the lower line clearly. The final result has been classified for sieve analysis test. A standardize upper and lower line are developed for all five Asean countries. Figure 5 has been made as it is consist of upper and lower line after all the finalized value plotted in graph and tabulated in Table 2. This study has proposed the graph shown that consist of upper and lower line as the new development of aggregate gradation for all the five Asean countries.

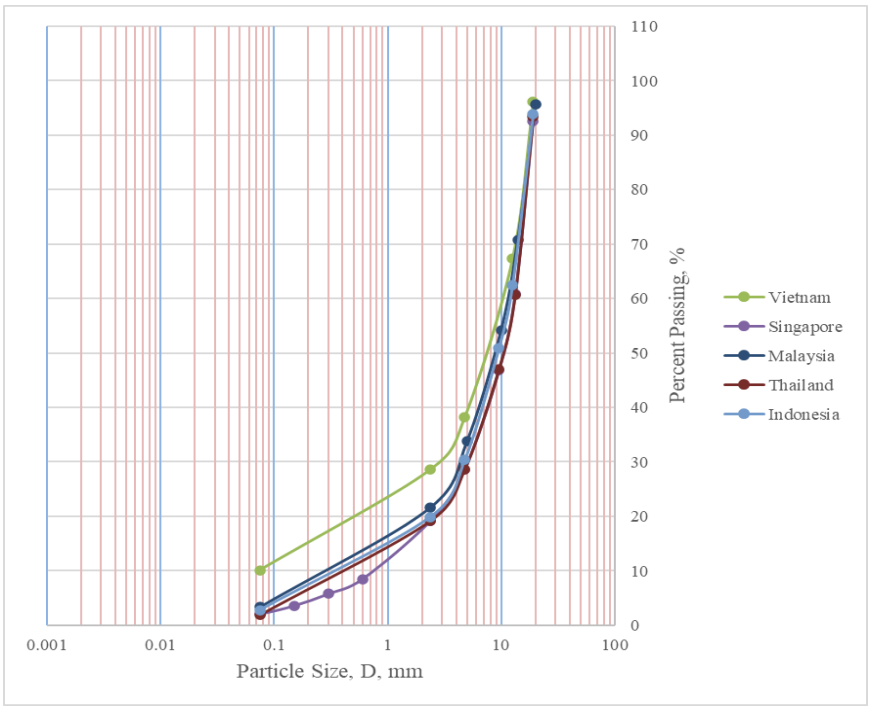

Figure 4. Average Aggregate Gradation Curve for all five asean countries

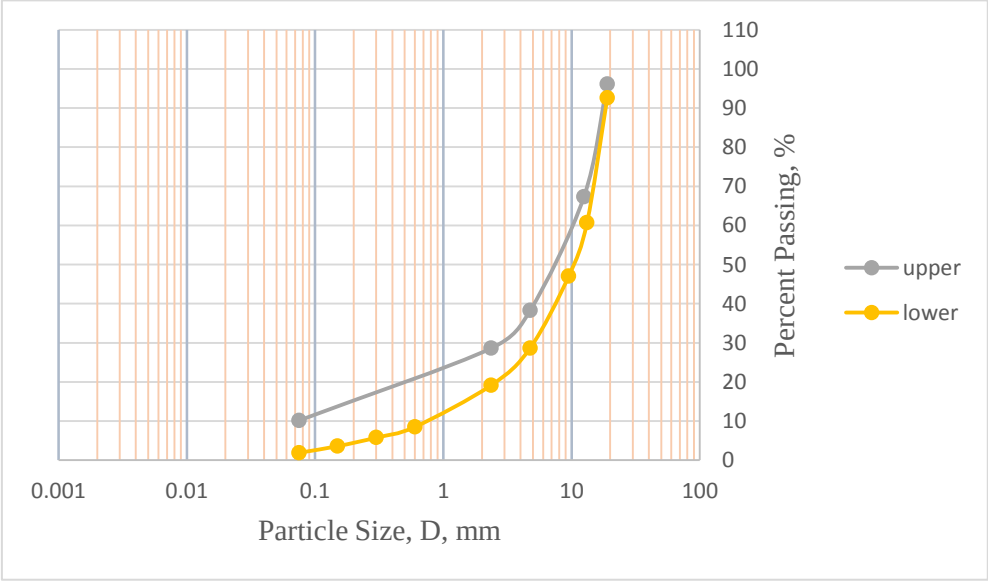

Figure 5. Lower and upper line Aggregate gradation curve

Table 2 Percentage passing for lower line and upper line

Sieve Size	Vietnam	Singapore
19.0	92.59	96.11
12.5	60.69	67.34
9.5	47.01	-
4.75	28.64	38.24
2.36	19.15	28.6
0.60	8.49	-
0.30	5.77	21.5
0.15	3.58	18
0.075	1.89	10.14

4. Summary

The development of the new aggregate gradation can significantly produce air voids consistently. The focus is made on the gradation and form of aggregate which essentially affect the properties of air voids content. The grading curves are studied in detail to know the behavior of coarse aggregate as well fine aggregate to have a better aggregate gradation. Therefore, it is crucial that coarse and fine aggregates are well graded to produce a better quality of asphalt mixture.

5. References

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Acknowledgments

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