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# Effect of aggregate gradation on rutting of asphalt concrete by using a wheel tracking device in Vietnam

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### Abstract:

This paper presents the relationship between rutting and aggregate gradation of asphalt concrete using a wheel tracking device at 60°C, with 30,000 cycles in air. The experiment was carried out on hot mix asphalt samples using three aggregate gradations which included maximum aggregate sizes of 9.5 mm, 12.5 mm and 19 mm. The result of the experiment showed that the maximum aggregate size has a great influence on the rutting of asphalt concrete.

Keywords: aggregate gradation, maximum aggregate size, rutting, wheel tracking

**DOI:** 10.1515/jmbm-2018-2007

# 1 Introduction

In recent years, early damage of asphalt concrete pavement has been a common issue in Vietnam, which reduces the quality of pavements and in particular, the phenomenon of rutting. Rutting is defined as the load-induced permanent deformation along the wheel path of flexible pavements due to the repeated movement of traffic . It is an accumulation of small deformations caused by repeated heavy loads. Rutting is one of the most dangerous forms of distress in pavements because it permits water to pond in the wheel path, which leads to hydroplaning and an increase in vehicle accidents. Much of this rutting can be attributed to improper mix designs [1].

As a result of the development of the Vietnam national economy, the numbers of vehicles have increased significantly in recent years which has led to higher demand of the increasing road system. The growth of vehicle numbers is shown in Figure 1 [2].

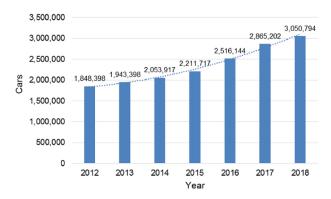


Figure 1: Growth of vehicles in Vietnam in the period 2012–2018 [2].

With the current situation of road traffic in Vietnam, the appearance of rutting is relatively common, especially on some of the main roads such as the National Highway 1, National Highway 3, National Highway 5, East-West Highway, etc. shown in Figure 2. In some instances, severe rutting occurred in the first summer after opening highways to traffic, such as the road passing through the Ha Nam province, the Thanh Hoa province part of the National Highway 1A, Phan Rang–Thap Cham route, etc.





**Figure 2:** Rutting in National Highway 1, Vietnam.

There are three basic types of asphalt pavement rutting: surface wear rutting, structural rutting and instability rutting. The types of asphalt pavement rutting are shown in Figure 3. The factors that influence the pavement rutting performance can be categorized into three groups: material properties, such as property of bitumen, binder content, aggregate property, etc.; climatic and traffic; and construction quality.

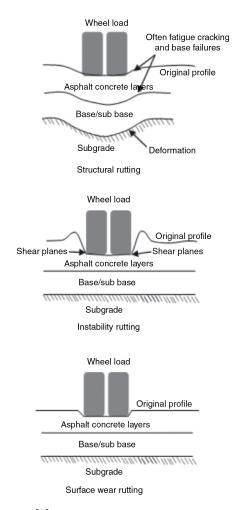


Figure 3: Types of asphalt pavement rutting [3].

Some studies demonstrate that the design of the aggregate gradations with the maximum aggregate size is considered to be resistant to rutting. However, the aggregate gradations needs to satisfy the fine aggregate filling the voids of the coarse aggregate, as well as the choice of maximum aggregate size of the coarse aggregate which depends on the thickness of the asphalt concrete layer and the current asphalt design standards [4], [5]. Therefore, the study of aggregate composition and considering the effect of maximum aggregate size on rutting is necessary. This paper presents the results of initial research in the laboratory about the effect of aggregate gradation on the rutting resistance.

# 2 Material composition

The mechanical properties of the material are in accordance with ASTM, AASHTO and Vietnam standards. Three types of aggregates gradation were designed and used with the maximum aggregate sizes of 9.5 mm; 12.5 mm and 19 mm.

# 2.1 Aggregate gradation

The proper combination of aggregate gradation improves the load bearing of the skeleton, which greatly influences the important properties of asphalt concrete. The grading curve of three types of aggregates gradation is shown in Figure 4.

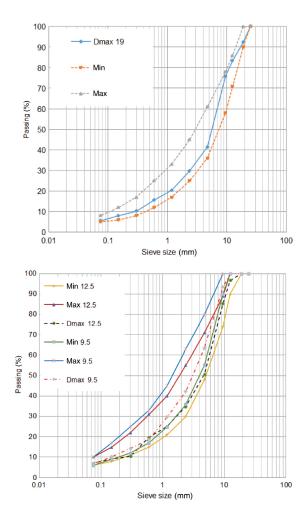


Figure 4: Grading curve graph.

Aggregate gradation and bitumen content are blended to create a mixture which has air voids ( $V_a$ ) of three design grades with maximum aggregate size of 19 mm, 12.5 mm and 9.5 mm is  $4\% \pm 0.5\%$ .

# 2.2 Type of aggregate

In this study, a kind of crushed aggregate and mineral filler, both manufactured from limestone, were used as the aggregate skeleton (Table 1). Some physical properties of aggregates are shown in Table 2.

Table 1: Aggregate gradations according to Vietnam standard TCVN 8819:2011 [6].

Sieve size (mm)			Passing (%)
	Sieve 9.5 mm	Sieve 12.5 mm	Sieve 19 mm
25	_	_	100
19	_	100	90-100
12.5	100	90–100	71–86
9.5	90–100	74–89	58-78
4.75	55–80	48–71	36-61
2.36	36–63	30–55	25-45
1.18	25–45	21–40	17–33
0.6	17–33	15–31	12-25
0.3	12–25	11–22	8–17
0.15	9–17	8–15	6–12
0.075	6–10	6–10	5–8

**Table 2:** Some physical properties of aggregates are used for the experiments.

Aggregate	Criteria	Unit	Results	Standard
Coarse aggregate	Maximum specific gravity	g/cm <sup>3</sup>	2.72	AASHTO T 84
	Bulk specific gravity	g/cm <sup>3</sup>	2.657	
	Absorption	%	0.90	
Fine aggregate	Maximum specific gravity	g/cm <sup>3</sup>	2.64	AASHTO T 85
	Bulk specific gravity	g/cm <sup>3</sup>	2.591	
	Absorption	%	1.79	
Mineral filler	Maximum specific gravity	g/cm <sup>3</sup>	2.2	AASHTO T 100

### 2.3 Bitumen

The asphalt binder used in this study was bitumen penetration grade 60/70, supplied by Petrolimex (Vietnam National Petroleum Group) with optimum asphalt content was 5.3%. Experiment of bitumen properties was carried out at the laboratory with Matest equipments imported from Italy. The properties of the bitumen are shown in Table 3.

**Table 3:** Properties of bitumen penetration grade 60/70.

Properties	Unit	Results	Standard
Specific gravity	g/cm <sup>3</sup>	1.015	ASTM D 70
Penetration at 25°C	0.1mm	65	ASTM D 5
Softening point	°C	49	ASTM D 36
Loss on Heating at 163°C	%	0.042	ASTM D 6
Flash point	°C	296	ASTM D 92
Ductility at 25 °C, 5 cm/min	cm	>100	ASTM D 113

# 3 Experiment

The research used British Standard- BS EN 12697-22:2003 [7], Method B with the Auto Lift Arm ECO Wheel Tracker (Cooper Technology) (small device). The input parameters of the experiment are as follows:

- Number of cycles: 30,000 cycles (60,000 passes).

- Wheel speed: 26.5 cycles per minute.

- Wheel load:  $700 \pm 10$  N.

- Temperature test: 60°C.

The aggregate mixture was dried to constant mass and then blended by a 40 l mixer, with calculated mass for each specimen. After blending, the mixture was poured into the mold with the size of 300 mm  $\times$  300 mm  $\times$  50 mm. It was compacted using a roller compactor. Table 4 illustrates the number of specimens for each gradation that were collected.

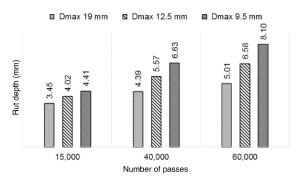
**Table 4:** Experimental plan for the number of specimens.

Gradations	Number of specimens	Number of cycles <sup>a</sup>
Maximum aggregate size 19 mm (Dmax 19 mm)	18	30,000 cycles or 60,000 passes
Maximum aggregate size 12.5 mm (Dmax 12.5 mm)	18	
Maximum aggregate size 9.5 mm (Dmax 9.5 mm)	18	

<sup>&</sup>lt;sup>a</sup>1 cycle = two passes of the wheel.

# 4 Test results

Rutting test results of three gradations after 30,000 cycles (60,000 passes) are shown in Figure 5.



**Figure 5:** Rutting test results at 60°C in air.

From the test results for the three gradations using the same type of asphalt binder at  $60^{\circ}$ C with 30,000 cycles (60,000 passes) in air, it shows that the resistant of rutting of maximum aggregate size of 19 mm is the best.

# 5 Conclusions

There are many factors which cause deterioration to asphalt concrete pavements. However, within the scope of the paper, the authors found:

- In the design of aggregate gradation consideration on the effect of maximum aggregate size, the rutting of maximum aggregate size of 19.5 mm has a better resistant than a maximum aggregate size of 12.5 mm and a maximum aggregate size of 9.5 mm.
- The comprehensive evaluation of the rutting of the asphalt concrete specimen in the laboratory requires more samples and more experiments on more types of aggregate gradation, types of asphalt binder, additive, load factors, temperature, the number of passes and the test environment.

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