Paving Methods Using a Multi Asphalt Paver

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ABSTRACT：Multi-asphalt paver (MAP) is an asphalt finisher and it can simultaneously handle two different types of asphalt mixtures. In case when MAP is used for upper and lower layers with different mixtures, the paving method is called Dual Asphalt Pavement method (DAP). Examples of this application include the construction of upper thin layer with porous mixture using small sized stones for noise reduction and/or drainage in performance based construction. When MAP is used for the construction of two different mixtures in the longitudinal direction, the method is called Multi Lane Pavement method (MLP). Application of anti-rutting mixture for heavy traffic road on limited part of the wheel path with the rest of the lane paved with normal asphalt mixture is an example of this method with less use of expensive modified asphalt binder. Generally, MAP method covers both of DAP and MLP. The MAP Technical Research Group in Japan is composed of eight companies (six machine owners, a machine maker and a trading company) in total. It has been promoting wider use of the paving method. During 10 years from its foundation until the end of March 2009, the areas paved by the DAP method amount to approximately 1,890,000 m^2 and those by the MLP method about 180,000 m^2.This paper describes the outline of MAP method and reports on construction projects using the MAP method in the past as well as the development of a smaller MAP with a similar function of the conventional machine.

KEY WORDS：multi-asphalt paver, dual asphalt pavement method, multi lane pavement method, low noise pavement, landscape pavement

1 INTRODUCTION

In Japan, the percentage of paved roads can be said to have increased with the development of proportion of the auto industry in the transport of goods and people. And sophisticated pavements have been developed and established which can respond to increases in size, speed and traffic volume of motor vehicles due to the industry's development. In recent years, needs for pavements have been diversified as is evident from increasing construction of porous pavements for the safety of motor vehicles, low-noise pavements for the benefit of roadside residents, functional pavements such as colorized bus lanes, growing demands for construction cost reduction and CO_2 emission reduction for global environment protection. Against such a background, the MAP Technical Research Group has developed a MAP which serves to make paving work more efficient and rational and thereby to enable shortening of work periods and efficient use of expensive materials for functional pavements and has made a study on the construction by the MAP of low-noise pavements, color pavements and landscape pavements. This paper presents the mechanism and features of the MAP and the characteristics of the paving methods using the MAP together with case examples of pavement construction.

2. MULTI ASPHALT PAVER

2.1 Description

The MAP, an asphalt paver with two sets of hoppers and screeds, is capable of paving two layers, upper and lower, or plural lanes with two types of asphalt mixtures concurrently. The method of paving the upper and lower layers with two types of asphalt mixtures concurrently is referred to as the DAP method, and the method of paving plural lanes with two types of asphalt mixtures concurrently is referred to as the MLP method. The former idea was also in Europe. However, its practical use proceeded in Japan. The MLP method was implemented for the first time in the world. The appearance of the MAP in the process of paving by the DAP method is shown in Photo 1.

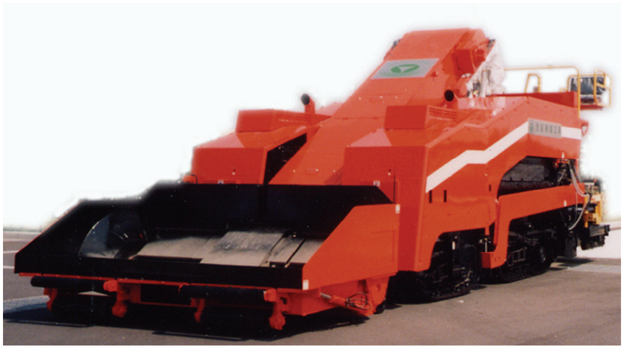

Photo 1: Appearance of MAP

The MAP specifications are listed in Table 1. In this table, the Nos. 1-8 machines produced so far are classified into three types by machine specifications.

Table 1: Specifications of the MAP

Item		Unit	TYPE Ⅰ Nos. 1-4 machines	TYPE Ⅱ Nos. 5-7 machines	TYPE Ⅲ No. 8 machine
Total length (at work)		mm	10,200	10,470	9,760
Total width (at work)		mm	2990		3,000
Total height (at work)		mm	3,800	4,220	4,250
Total weight		kg	25,000	27,500	23,500
Paving width		m	2.5-6.0		2.5-4.5
Engine output		kw	96 ×2 units	138 × 2 units	132.1
Running speed (at work)		m/min	1-10		1.5-12
Screed	Upper layer		Tamper vibrator type		
Screed	Lower layer		Tamper type	Tamper vibrator type	Tamper type
Hopper capacity	Upper and lower layers	m^3	Upper and lower layers: 6.5 each		Upper layer: 6.5 Lower layer: 2.8

2.2 Features of the MAP

The features of the MAP are as follows:

1) The MAP is a machine equipped with a mixture feeder and two sets of downsized compact hoppers and screeds.
2) Two screeds are attached to a pair of leveling arms, so the spreading thickness is easily changeable.
3) The leveling arm is longer than that of an ordinary finisher, so surface smoothness can be expected to be ensured.
4) The machine is an all-wheel drive type and has a minimum turning radius equal to that of an ordinary finisher and is excellent in trackability at the time of constructing curves.
5) Many of the machine types have a hopper capacity of loading more than one dump truck (10-ton) for continuous pavement construction.

The No. 8 machine shown in Photo 2 is a new type brought to completion in December 2008, which is designed to be smaller in size than conventional machines as shown in Table 1. Different from the conventional type with two engines, the No. 8 machine (Type Ⅲ) has one engine, but is equivalent to the former in working capability. Therefore, it satisfies the standard values for both exhaust gas and noise of construction machines designated by the Ministry of Land, Infrastructure and Transport and enables 50% reduction of fuel consumption and CO_2 emissions (Sekiguchi, 2009).

Photo 2 : Appearance of No. 8 Machine (Type Ⅲ)

3 DAP METHOD

3.1 Mechanism (transfer and compaction of asphalt mixture)

A transfer flow of the asphalt mixture fed to the MAP is shown below and a transfer route in Figure1.

1) The asphalt mixture for the lower layer or for the upper layer is fed to the charging hopper.
2) A flight conveyor is used to transfer the asphalt mixture for the upper layer to the hopper for the upper layer and the asphalt mixture for the lower layer to the hopper for the lower layer. The damper positions are changed to switch between the hoppers to which to transfer the asphalt mixture.
3) The asphalt mixture for the lower layer is transferred to the lower layer screed by a bar feeder, and the asphalt mixture for the upper layer is transferred to the upper layer screed by a spread roll or screw.
4) The asphalt mixture fed to the upper/lower layer screed is compacted by the action of a tamper vibrator. In the case of the Type Ⅲ and Type Ⅰ machines, the asphalt mixture fed to the lower layer screed is compacted by the action of the tamper only.

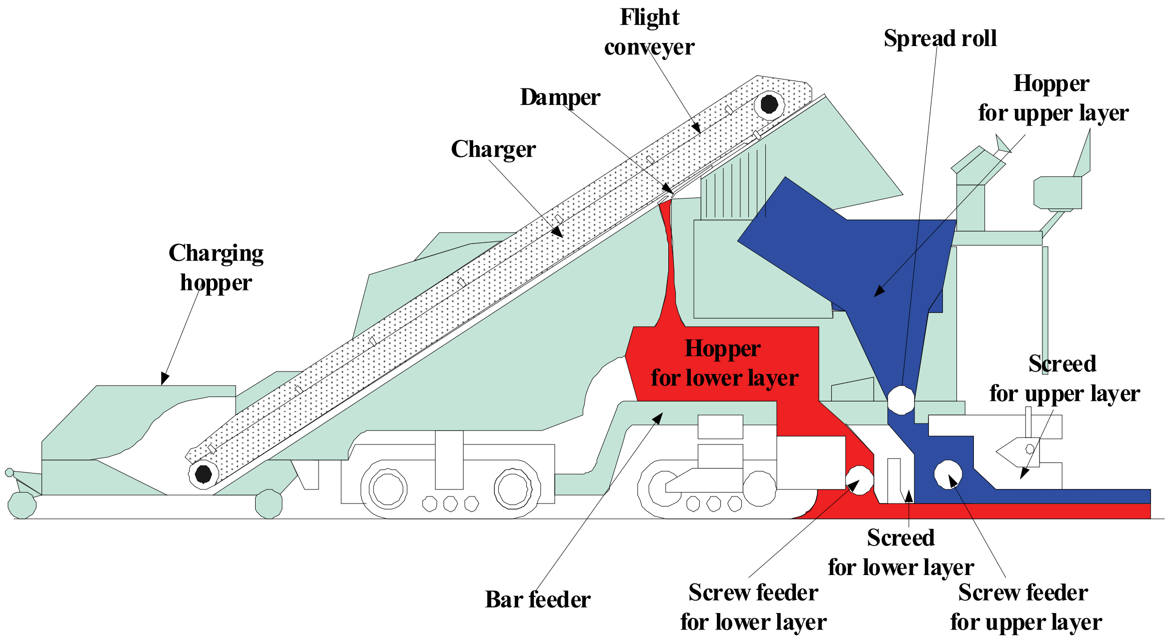

Fig. 1 : Transfer Route of Asphalt Mixture in the case of uing the DAP method

3.2 Characteristics of the Method

The characteristics of the DAP method are as follows:

1) When designing pavements such as cooler pavement that uses a pigment or decolorized asphalt, the paving cost can be reduced by dividing the surface course into two layers, upper and lower, and applying the higher-cost asphalt mixture for the upper layer only.
2) The two layers can be paved concurrently by feeding the mixture for the surface course and the mixture for the base course to the MAP, so it is clear that a tack coat between the layers is not necessary. Therefore, the paving cost can be reduced.
3) The maximum spreading thickness of the upper layer is 60 mm, the minimum spreading thickness of the upper layer is 20 mm and the maximum spreading thickness of the two layers is 120 mm.
4) One layer placement by using the upper layer screed enables the maximum spreading thickness of 200 mm.

3.3 Pavement Applying the DAP Method

Figure 2 shows an example of the pavement structure applying this method. As shown in Figure 2, the DAP method can be classified broadly into a method of dividing the surface course (4-7 cm thick) into two layers, upper and lower, and paving them concurrently and a method of paving the surface and base courses (8-12 cm thick in total) concurrently. The method of dividing the surface course into the upper and lower layers can be classified broadly into a dual-layer low-noise pavement method applying a porous mixture for the upper and lower layers and a thin-layer pavement method applying a mixture with a specific feature such as color mixture and anti-freezing mixture, for the surface course.

A description is made here of special techniques for controlling workmanship and quality which are different from those used for ordinary pavement construction.

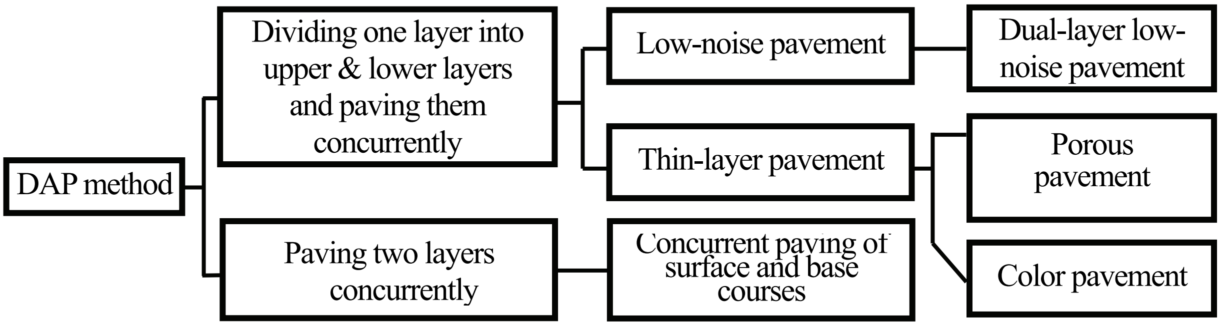

Fig. 2 : Example of Pavement Constructed by DAP

1) Workmanship control (thickness control)

In the case of paving by the MAP, a spreading thickness is set for the upper layer and the whole layers. so the lower layer serves as a leveling layer to correct the unevenness of the paving foundation. For the sake of paving thickness control, therefore, the upper layer thickness and total layer thickness of a specimen are determined by a measuring device such as caliper and the lower layer thickness is calculated by subtracting the upper layer thickness from the whole layer thickness.

2) Quality control (degree of compaction)

The standard density of a combination of the upper and lower layer sections of the specimen (hereinafter referred to as the combined standard density) is calculated by equation （1） and the degree of compaction of the specimen is determined by equation （2） applying its density:

Combined standard density = (standard density of upper layer mixture) ×(upper layer thickness) / (whole layer thickness) （1）

Degree of compaction = (density of specimen) / (combined standard density)×100 （2）

(1) Dual-layer low-noise pavement

1) Description

The dual-layer low-noise pavement by the DAP method is a pavement in which the surface course is divided into the upper and lower layers and porous asphalt mixtures different in maximum aggregate grain size are applied for them. Usually, the surface course is formed of two layers by using a porous asphalt mixture 5-10 mm in maximum aggregate grain size (hereinafter referred to as the small grain size porous asphalt mixture) for the upper layer and a porous asphalt mixture 13 mm in maximum aggregate grain size (hereinafter referred to as the ordinary porous asphalt mixture) for the lower layer. Photo 3 shows an example of the layer structure of the low-noise pavement in which the small grain size porous asphalt mixture 5 mm in maximum aggregate grain size is used for the upper layer and the ordinary porous asphalt mixture for the lower layer.

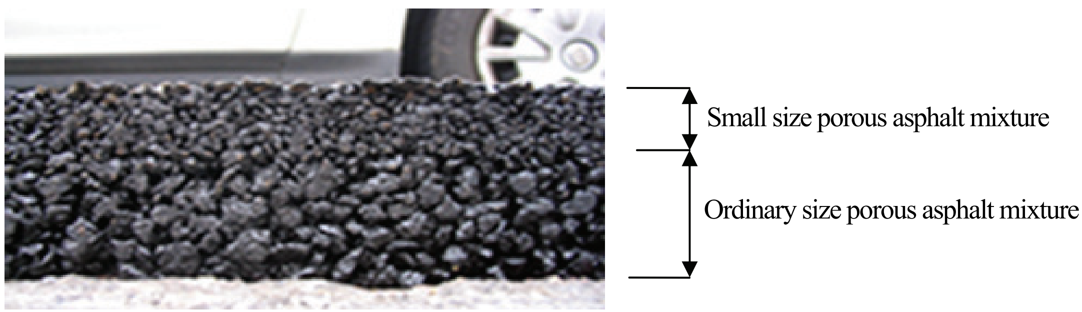

Photo 3 : Example of Layer Structure of Dual Layer Low Noise Pavement

2) Performance and effect

Figure 3 shows the results of the tire/road noise measured on various pavements including dual-layer and single-layer low-noise pavements on selected Tokyo metropolitan highways. According to the results of tire/road noise measured by a pavement surface noise level measuring vehicle, a noise reduction effect of about 2-3 dB as compared with ordinary low-noise pavements is obtained though the degree of noise reduction varies with such conditions as the roadside and traffic volume, (Takeda, 1999). The small grain-size porous asphalt mixture is inferior to the ordinary porous asphalt mixture in rutting resistance. However, it can be confirmed that its dynamic stability is expected to improve by adopting the dual-layer structure in which an aggregate larger than that of the upper layer is used for the lower layer as shown in Table 2.

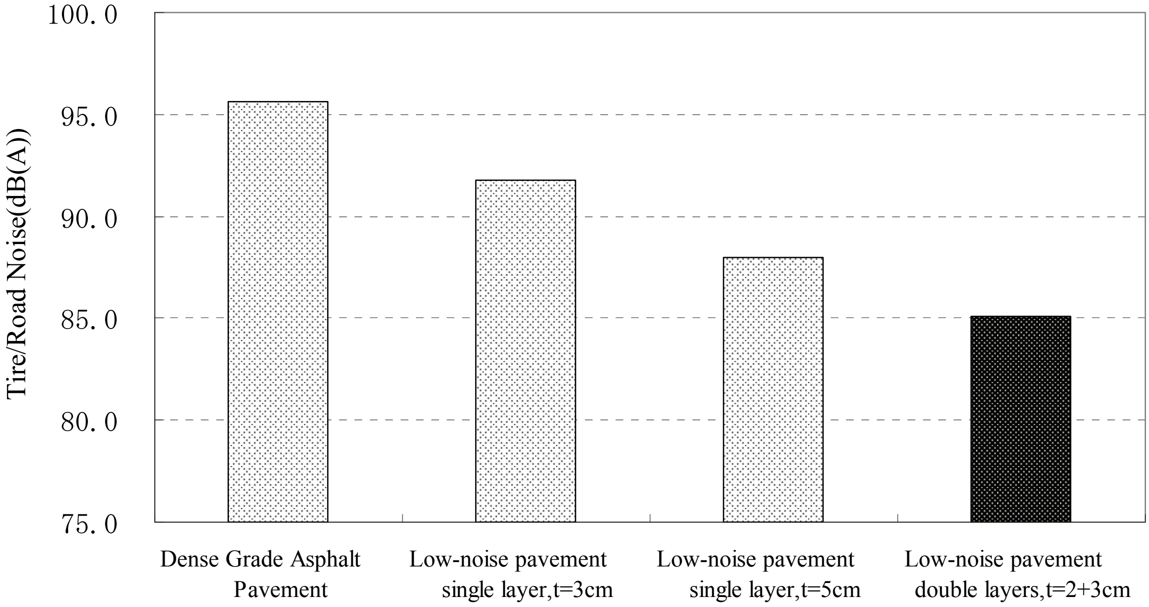

Fig. 3 : Tire/Road Noise by Tyepes of Pavements

Table 2 : Dynamic Stability (DS) of Dual Layer Porous Asphalt

No	Name of mixture		Max. aggregate grain size (mm)	Void ratio (%)	Layer thickness (cm)	DS of layer (cycles/mm)	DS of dual-layer specimen (cycles/mm)
1	Upper layer	Small grain-size porous asphalt mixture	5	22.6	2	3,316	5,250
	Lower layer	Ordinary porous asphalt mixture	13	20.3	3	7,000	
2	Upper layer	Small grain-size porous asphalt mixture	8	23.1	2	4,900	7,000
	Lower layer	Ordinary porous asphalt mixture	13	19.3	3	8,800	

(2) Thin-layer porous asphalt (see Figure 4)
1) Description
The porous asphalt mixture and the impermeable layer beneath it are placed concurrently to make the porous pavement into a thin-layer structure.
2) Performance and effect
The consumption of the expensive porous asphalt mixture can be decreased, so the paving cost can be reduced by 10% as compared with the cost of paving with a thickness of 5 cm.

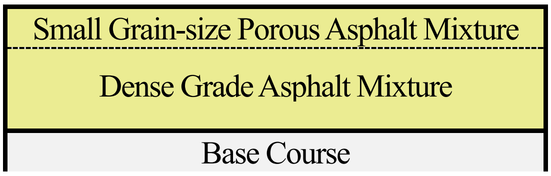

Fig. 4 : Thin Layer Porous Pavement

(3) Color pavement (see Figure 5)
1) Description
The mixture used for color pavement is a very expensive material because it uses a color aggregate, decolorized binder or pigment. The color pavement is made into a thin-layer structure by placing the color mixture and ordinary mixture beneath it concurrently.
2) Performance and effect
The consumption of the expensive porous asphalt mixture can be decreased, so the paving cost is reduced by 20-40% as compared with the cost of paving with a thickness of 5 cm. The degree of cost reduction varies with the type of mixture used.

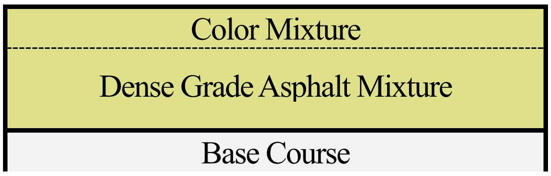

Fig. 5 : Color Pavement

(4) Concurrent paving of the surface and base courses (see Figure 6)
1) Description
Different from the usual practice of paving the surface course after paving the base course, the surface course and base course mixtures are placed concurrently.
2) Performance and effect
The two layers can be paved concurrently, so it is possible to shorten the process and lessen the effects on the traffic around the work site.

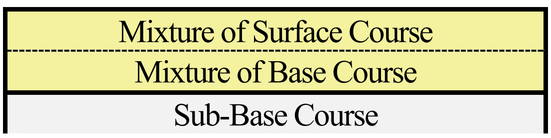

Fig. 6 : Concurrent Paving of Surface and Base Courses

3.4 Amount of Construction

According to the data on pavement construction by the MAP group for the period of 10 years from February 1999, when the pavement was constructed by the MAP method for the first time on a Metropolitan highway, to March 2009, an area of about 2,000,000 m^2 was paved by the DAP method as shown in Figure 7.

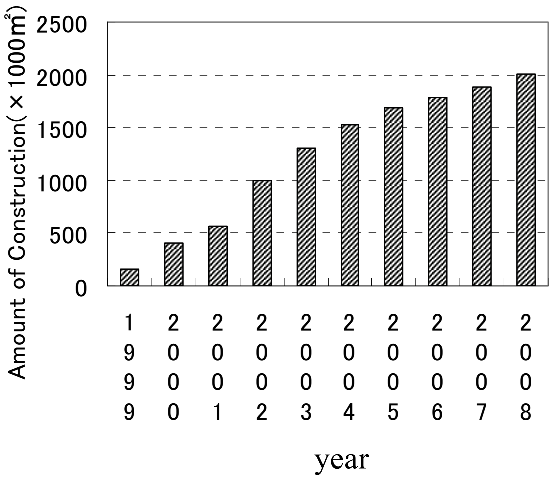

Fig. 7 : Trend of Paving by DAP Method

4 MLP METHOD

4.1 Mechanism (transfer and compaction of mixture)

A transfer flow of the asphalt mixture fed to the MAP is shown below, and an image of the spread mixture is given in Figure 9.

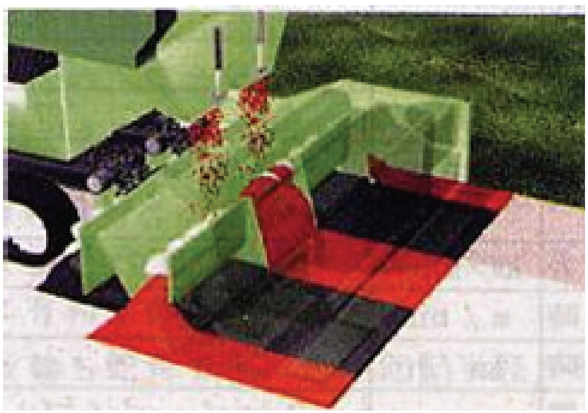

Fig. 9 : Image of Spread Mixture

The flow of the mixture from the point of feeding to the MAP to that of the hoppers for the upper and lower layers is the same as that described in Items 1),2) and 3), Paragraph (1) of Section 3.1

"Mechanism (transfer and compaction of mixture)."
4) The mixture for the sections of wheel paths (colored black in Figure 9) is stored in the hopper for the lower layer and the mixture for the section of between them in the hopper for the upper layer.
5) As the lower layer screed is removed at the time of unit change, the mixtures for wheel paths and the section of between them are compacted by the action of the tamper vibrator by the upper layer screed.

4.2 Characteristics of the Method

The characteristics of the MLP method are as follows:
(1) The width of each wheel paths 1,000 mm and the width of the middle 710 mm.
(2) Two wheel paths and the middle can be shifted 80 mm horizontally at the time of paving.
(3) As this method applies a mixture for specified purposes, for the section of wheel paths only, pavement construction can be done inexpensively as compared with the method of applying the mixture over the entire width.

4.3 Pavements Applying the MLP Method

(1) Rutting resistance and wear resistance pavements
1) Description
Rutting-resistant and wear-resistant pavements can be constructed at a reduced cost by applying a rutting resistance and a wear resistance asphalt mixtures for the sections of wheel path and an ordinary asphalt mixture for the section between them. Photo 4 shows an appearance of the pavement after put into service. The paving thickness is 4 cm. A dense-graded asphalt mixture using polymer-modified asphalt is applied for the section of wheel path (the section deep in color in Photo 4) and a recycled mixture for the middle section (Photo 4) .

Photo 4 : Rutting Resistant Pavement

2) Performance and effect
The consumption of the expensive material can be decreased by using a rutting-resistant or wear-resistant mixture for the sections between the wheel paths, so that it becomes possible to achieve a cost reduction of about 10%.
(2) Landscape pavement (see Figure 10)
1) Description

A pavement excellent in appearance is constructed by using two types of mixtures of different colors alternately for five paths.

2) Performance and effect

The consumption of the expensive material when combined with an ordinary mixture can be decreased as compared with that in the case of full-width color pavement so that it becomes possible to achieve a cost reduction of about 10%.

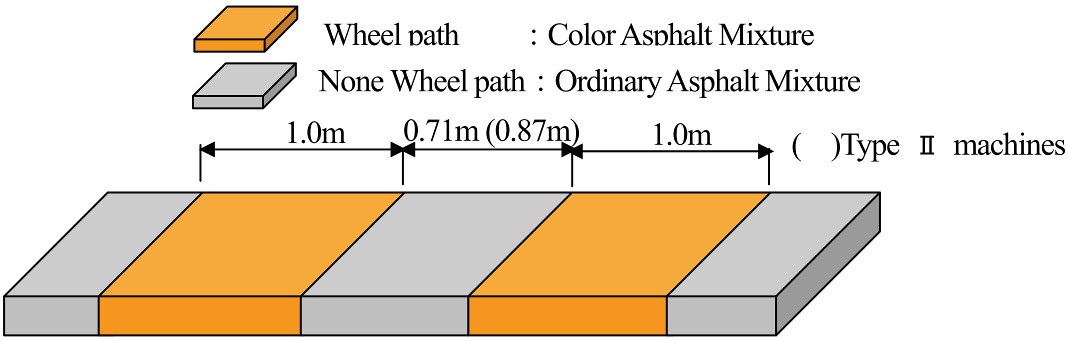

Fig. 10: Landscape Pavement using Type Ⅰ or Ⅲ machines

4.4 Amount of Construction

The MLP method is intended mostly for the construction of rutting resistance pavements using a modified asphalt mixture for the sections of wheel path path. So far, a total area of 200,000 ㎡ has been paved by this method.

5 CONCLUSION

Various paving methods using MAP have been described here, by which low-noise pavements or thin layer pavements can be constructed. Rutting-resistant and wearing-resistant pavements can be constructed economically. Concerning low-noise pavements using the DAP method, a confirmation was made of a tire/road noise reduction effect of 2-3 dB as compared with low-noise pavements using the ordinary finisher. Rutting-resistant and wearing-resistant pavements only applied for wheel paths by using the MLP method, can achieve a cost reduction of about 10%. Further studies are needed on the mechanism and structure of the machine with the objective of improving workability and operating efficiency among others.

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