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ANALYSIS INFLUENCE OF CEMENT OF THE ASPHALT PAVEMENT DEMOLITION MATERIAL ON ROADS *SEMARANG-DEMAK-INDONESIA*

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Abstract: The aim of this study is to determine levels of cement that can be used for the top layer foundation (base course) with recycled asphalt materials mixed cement on road rehabilitation Semarang – Demak. This study uses an experimental method in the laboratory with a cylindrical specimen diameter of 7 cm height of 14 cm made of cement content variation 0%, 1.5%, 3%, 4.5%, 6% and 7.5% is used for testing the uncondifined compressive strength / (UCS) at the age of 7 days, 21 days, 14 days and 28 days. The results show that the addition of cement content will increase the value of the dry weight insignificantly, but will rise UCS value significantly and utilization of scratching asphalt cement with added material from these laboratory experiments can increase the carrying capacity CTRB construction. Levels of cement that meets the requirements of Unconfined Compressive Strength (UCS) for the construction of Cement Treated Recycling Base (CTRB) is between 6% to 7.5%. According to the results of research it is economically to used cement content at average of 6.75% for road rehabilitation works Semarang - Demak has met the required UCS test.

Keywords: Cement; recycling, uncondifined compressive strenght

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INTRODUCTION

Recycled pavement material is the use of pavement old (existing), which is processed into a new pavement layer using either additive (additive) or not for maintenance work, repair or improvement of pavement construction. Pavement recycling technology as an alternative technology of conventional technology which is usually done by repeated layering (overlay) on the old pavement so that it will be problems in the future, especially the increase in the elevation of the road (Moon *et al.,* 2014; Perez *et al.,* 2013). Pavement material consisting of crushed stone and asphalt as a binder having raw nature so that they can be reused for recycling pavement construction. Environmental considerations that overlay will add to the high layers of the road surface so that the effect on the surrounding environment, especially in urban settlements drainage system adjacent to the road and could ultimately lead to flooding (Dongxin *et al.*, 2010; Iwanski, 2011).

The use of waste materials highway can save natural resources and cost about 20 to 40 percent, fuel-efficient and faster process 30 to 40 percent compared with the construction work with new materials (Filippo, 2011). The addition of cement in the mix even though the percentage of recycled significantly increases the load bearing strength (Jitareekul, 2007).

Reclaimed Asphalt Pavement (RAP) has the same strength compared with the construction using new materials (natural resources). RAP is an alternative design to the construction works its way through the process of research and construction so that the RAP approach can be used in the field (Locander, 2009; Yang *et al.,* 2013). Construction of road pavement recycling more efficient and to increase the strength of the material can be stabilized by using Portland Cement (Lario, 2000).

The concept of sustainable development is crucial in the selection of building materials usage. Effect of the use of construction materials on the environment should be considered through careful analysis with a simple analogy ranging material taken from nature, used in building construction and recycling of these materials. The use of appropriate building materials, efficient, and environmentally friendly, minimize waste, reduce consumption of non-renewable natural resources with the optimization of alternative raw materials, and energy savings overall. Sustainable construction was done by using alternative materials and alternative fuels that can reduce CO_2 emissions into the air (Nicuta, 2011). According Resmi *et al.* (2011); Viera *et al.* (2015), which referred to the Green Building Materials is a building material that is undergoing a process of transformation or technology changes the less, do not damage the environment, and do not interfere with human health. The concept of resource management in terms of economic and environmental aspects is the term eco-efficiency is an economic concept of using resources effectively to meet human needs. When activity increases, the efficiency of resource use decreases so that the cost of production decreases. When the cost of production decreases, the gain/profit rose and enhance product competitiveness (Khosla *et al.,* 2012).

Judging from the environment where activities increased efficiency then reduce wasted resources. When resources are wasted the smaller the amount of waste decreases so that the potential environmental impacts of declining to make eco-friendly production. (Hajj *et al.,* 2008).

MATERIALS AND METHODS

The study was conducted with the laboratory experimental method to acquire desired data in Semarang – Demak (**Fig. 1**). Purpose of the study is to determine the UCS, and the amount of cement mixture CTRB (**Fig. 2**).

Fig.1 Research sites on road Semarang – Demak

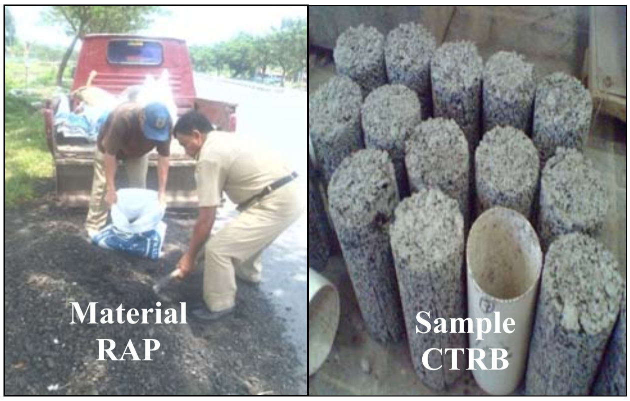

Fig.2 Material RAP and simple CTRB

Data Collection Technique

Technique of data collection is done by collecting primary data and secondary data. Primary data is data obtained directly from the implementation of the research in the laboratory are:

(a) Abrasion aggregate, (b) Unconfined Compressive Strength, (c) The amount of cement used to obtain a certain compressive strength, (d) The optimum water content, (e) The weight of dry contents, (f) Specific gravity and absorption of fine aggregate, (g) Specific gravity and absorption of coarse aggregate. Secondary data was obtained from existing data and of scientific books that are still associated with this research.

Research Materials

The materials used in the study are: (a) Reclaimed Asphalt Pavement (RAP) is taken from Semarang-Demak road, (b) The cement used is Portland Cement type I, (c) The water used is water from Materials Laboratory Department of Civil Engineering of Islamic Sultan Agung University which is suitable for consumption as drinking water.

Test objects

The specimens will be made in this study are: UCS test using a cylinder with a diameter of 7 cm and height of 14 cm, and number of test specimens as much as 5 pieces for each cement content variation.

Table 1 Criteria for the strength of recycled pavements mixture with cement

Allotment	Uncondifined compressive strength at the age of 7 days (Kg/cm^2)	
	UCS (diameter 70 mm x 140 mm)	Compressive strength of concrete cylinders (diameter 150 mm x 300 mm)
Base foundation layer	Min 30	15 – 30
Sub base foundation layer	Min 20	7.5 – 15

To get the unconfined compressive strength of the specimen is done by calculating:

$$f'c = P/A \quad (1)$$

where f'c = Unconfined Compressive Strength Values (MPa), P = Maximum load (KN), A = Surface area of the test specimen depressed (cm^2)

RESULTS AND DISCUSSION

Asphalt Scratching Materials Examination Results (RAP)

Examination of asphalt scratching material aggregate (RAP) in the laboratory includes abrasion, water content of fine aggregates, mud content of fine aggregate, mud content of coarse aggregate, organic matter content, aggregate abrasion, specific gravity, absorption of coarse aggregate and fine aggregate, liquid limit and plastic limit as shown in **Table 2** below.

Table 2 Results of RAP Examination

No	Examination Name	Result
1.	Abrasion	45,49 %
2.	Water content	4.23%
3.	Mud content of coarse aggregate	1.4%
4.	Specific gravity of coarse aggregate	2.738
5.	Specific gravity of coarse aggregate	2.784
6.	Absorption of coarse aggregate	2.688
7.	Absorption of coarse aggregate	2.786
8.	Plastic index	0.00

Reclaimed Asphalt Pavement Gradation Examination

Gradation scratching material in this study refers to (ASTM, 2004) gradation examination of RAP is obtained the results as **Table 3** below.

Table 3 RAP gradation sieve analysis results

Sieve Number ASTM	mm	Requirements of sieve passing	% cumulative retained	% passing
1 ½ "	37.5	100	0	100
1"	25	79 – 85	22.92	77.08
3/8"	9.5	44 – 58	44.5	55.52
No.4	4.8	29 – 44	59.9	40.11
No.10	2.0	17 – 30	80.7	19.33
No.40	0.425	7 – 17	90.7	9.31
No.200	0.075	2 – 8	97.1	2.86
Pan		0	100.0	0.00

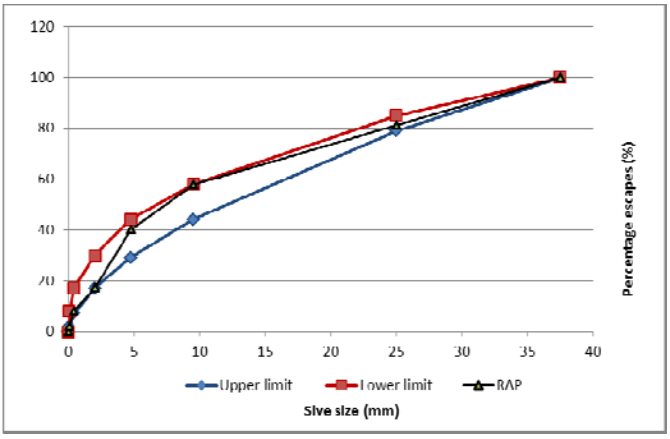

Fig. 3 Graph of the sieve analysis results

From the examination results of the RAP gradation as shown in **Table 3** and **Fig. 3**, so the RAP gradation meets the requirement of mixture gradation recycling old pavement layers of a mixture of cement as the foundation layer on Cement Treated Recycling Base (CTRB).

Optimum Water content

The optimum water content is obtained based on the value of the maximum density achieved with heavy density testing. To determine the optimum water content graphed the relationship between the water content with a maximum dry weight unit (γd).

Table 4. Examination Results of Optimum Water content and Dry Weight contents (γd)

Cement content	Optimum Dry Weight content (γd)	Optimum Water content (%)
0%	2,049	8.00
1.5%	2,051	7.90
3.0%	2,052	7.50
4.5%	2,053	7.10
6.0%	2,054	6.80
7.5%	2,055	6.60

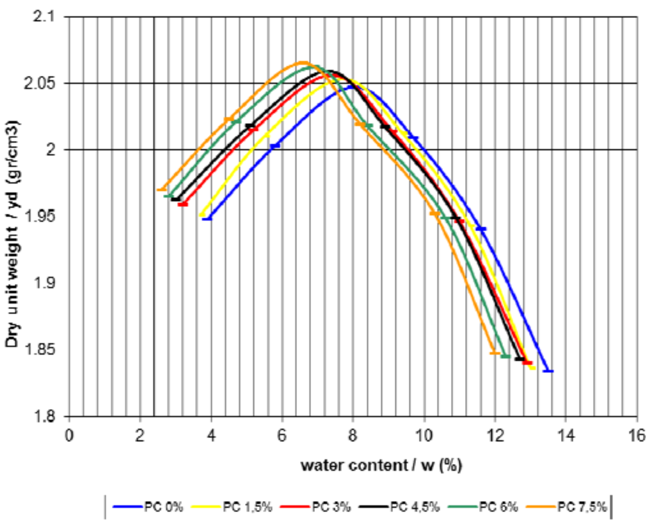

Fig. 4 Graph of the optimum water content resulting in6cement content variation.

Test Results of Specimen

The test specimen of CTRB includes UCS. For the manufacture of unconfined compressive strength specimens using 100% RAP without the addition of new aggregate (ASTM, 2017).

Table 5 Test results of material needs calculation

Cement content	UCS Age of 7 days (Kg/cm^2)	UCS Age of 14 days (Kg/cm^2)	UCS Age of 21 days (Kg/cm^2)	UCS Age of 28 days (Kg/cm^2)
0	0	0	0	0
1.5	12.03	13.49	14.71	16.24
3	16.09	18.52	19.91	21.35
4.5	20.52	21.98	23.04	26.45
6	26.2	27.47	28.48	30.42
7.5	35.1	36.36	37.62	40

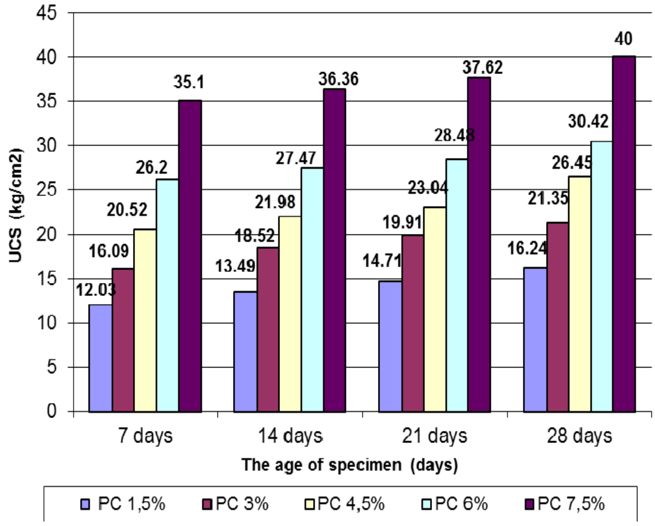

Fig. 5 Graph of the compressive strength of Cement Treated Recycling Base

Table 6 Correlation between the levels of cement with UCS values

Specimen	Correlation equation UCS	R^2
UCS age of 7 days	y = 3.75x + 5.113	0.9713
UCS age of 14 days	y = 5.549x + 6.653	0.9697
UCS age of 21 days	y = 5.439x + 8.435	0.9645
UCS age of 28 days	y = 5.659x + 9.915	0.9744

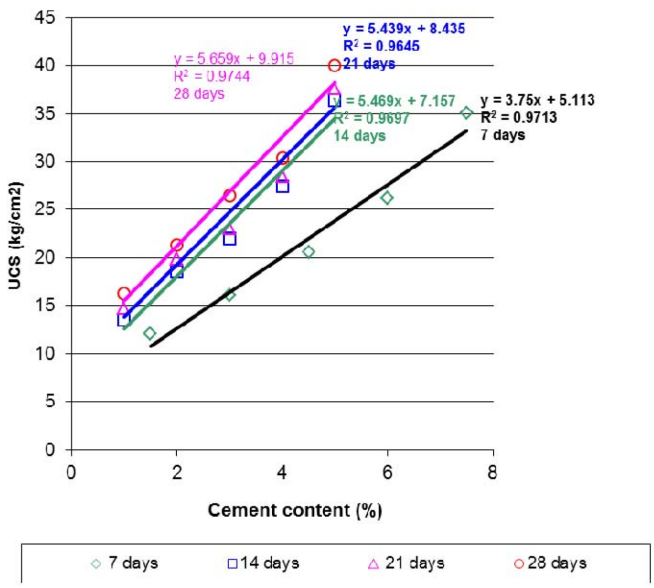

Fig. 6 Correlation between the levels of cement with UCS values

Compressive strength and tensile strength is achieved a stabilized material with cement materials are largely determined by the amount of cement added, the type of material and the density of the material mixed (Wirtgen, 2004; Jimenez, 2013; Cascione *et al.,* 2015). Effect of cement content on the uncondifined compressive strength at the age of maintenance 7 days, 14 days, 21 days and 28 days can be seen in **Fig. 5**.

From **Fig. 5** it is known that the higher levels of cement, unconfined compressive strength value is greater. The addition of Portland Cement can improve the compressive strength and increase the carrying capacity CTRB (Del Rey *et al.,* 2015; Herrador *et al.,* 2012; Wu *et al.,* 2013).

Figure 6 shows that the relationship between cement content and uncondifined compressive strength time on each treatment shows that the coefficient of determination (R^2) of 0.9713 or to the age of 7 days treatment by 97.13%, to 14 days of age treatment for 0.9697 or 96.97%, to age care 21 days 0.9645 or 96.45% and for the 28-day treatment at the age of 0.9744 or 97.44%.

The value of the coefficient of determination (R^2) between 0 and 1 as well as the correlation coefficient (R) has a value that is at the root of the coefficient of determination. The greatest value of r + 1 and r is the smallest is -1. The value of r = +1 indicates a perfect positive correlation, while the value of r = -1 indicates a perfect negative correlation. r does not have units or dimensions. The + or - just show the direction of the relationship. This shows that there is a very strong relationship between the levels of compressive strength of cement-free which is a requirement correlation ($-1 \leq r \leq 1$)

CONCLUSION

From these results it can be concluded as follows:

(1) The addition of cement content will increase the value of the dry weight insignificantly, but will rise UCS value significantly and utilization of scratching asphalt with cement added material from these laboratory experiments can increase the carrying capacity on CTRB construction.

(2) Levels of cement that meets the requirements of UCS for the construction of CTRB is between 6% to 7.5%. According to the results of research it is economically to use cement content at average of 6.75% for road rehabilitation works Semarang - Demak has met the required UCS test.

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