

Comparative Study of Bio-Asphalt, Coconut Shell Distillation Tar, and Plastic Road in terms of Construction, Economical, and Regulatory Aspects

Arthur Daniel Limantara

Department of Informatics Engineering, STT Cahaya Surya, Perintis Kemerdekaan 36A, Kediri,
East java, Indonesia
arthur.limantara@gmail.com

Edy Gardjito, Bambang Subiyanto and Fauzie Nursandah

Department of Civil Engineering, Kadiri University, Selomangleng 1, Kediri, East Java,
Indonesia
edi_gardjito@unik-kediri.ac.id , bambang_subiyanto@unik-kediri.ac.id ,
fauzie_nursandah@unik-kediri.ac.id

Adisty Riska Hardianti

Department of Economic, Kadiri University, Selomangleng 1, Kediri, East Java, Indonesia
adisty_riska@unik-kediri.ac.id

Hery Lilik Sudarmanto

Department of Law, Kadiri University, Selomangleng 1, Kediri, East Java, Indonesia
hery_lilik@unik-kediri.ac.id

Abstract

Sustainable development driven in Indonesia, especially for green roads has also begun. In some previous research papers have been done to get a picture of readiness both the government and business actors contractors and consultants are ready. But still encountered some obstacles in such a limited budget; lack of regulation; no government incentives for construction industry actors; expensive initial investment in technology; lack of technical specifications and implementation guidelines; lack of socialization of green road assessment system; lack of exercise; lack of expertise in government, contractors and consultants; lack of understanding and willingness; no request; Lack of tools that use environmentally friendly energy. This paper aims to provide a comparison of several types of materials such as Bio-asphalt, Coconut Shell Distillation, and Plastic Waste to reduce the use of asphalt in terms of construction, economic and legal aspects so that it can serve as a guide for evaluation. Bio-asphalt from algae can be used as a substitute for asphalt or used to reduce, while the Distillation of Coconut Shells and Plastic Waste can only be used to reduce the use of asphalt from petroleum. The future expectation of all road infrastructure development in Indonesia has a good green road rank

Keywords

Comparative Study, Bio-Asphalt, Coconut Shell Distillation, Plastic Road.

1 INTRODUCTION

In the era of President Joko Widodo has been committed in an effort to improve the sector of environmentally sustainable development, as well as the transport infrastructure, especially roads and bridges. In addition to infrastructure, efforts are also made to promote the use of renewable energy such as electric motorcycles and to build a common electric charging facility (SPLU).

The application of green technology has entered a new phase starting with green buildings that have been implemented in Jakarta and Bandung. While the green road is still in the stage of the implementation process. Readiness to implement green roads both government and business actors i.e. contractors and consultants are ready, but still encounter some obstacles in such a limited budget; lack of regulation; no government incentives for construction industry actors; expensive initial investment in technology; lack of technical specifications and implementation guidelines; lack of socialization of the green road assessment system; lack of exercise; lack of expertise in government, contractors and consultants; lack of understanding and willingness; no request; lack of tools that use environmentally friendly energy (Mustofa et al., 2017).

In solving the above problems, we conduct comparative studies of some pavement materials such as bio-asphalt, coconut shell distillation and plastic roads in terms of construction, economic and regulatory aspects so that it can be a solution in the technical specifications and implementation guidelines. Besides, because it is reviewed from economic aspect and regulation, this paper is also expected to give a description about the incentive that can be obtained and become a basic regulation for regulation adjustment.

2 GREEN ROAD CONCEPTS

According to the R & D center and the bridge states the concept of green road features is the application of technology to materials that can be reduced, reuse and recycling. This is an effort to tackle problems of depletion of natural resources, as well as restore pavement strength and maintain road geometry and dependence on new material.

More specifically, In the implementation of the reduce, reuse and recycling method, this road pavement recycling technology has 2 techniques, namely the recycling of in-place and in-site plant. The process of recycling in the field is more efficient because at the stage of raking, forming and compacting, directly on the spot. While in the recycling process at the mixer, the results of the scratching are first brought to the mixer for improved quality and quantity (Sipes and Sipes 2013).

In the aspect of law or regulation to green construction, practices must meet several criteria as shown in Table 1 (Sipes and Sipes 2013).

Table 1: Criteria for Green Construction Practices.

Build for the long-term
Schedule construction to minimize impacts
Consider the overall energy use of a project
Emphasize reuse and recycling
Clear the site only within the limits of construction
Protect important environmental, landscape, and cultural features
Coordinate with construction personnel when planning and designing projects
Ensure that erosion and sedimentation are controlled during construction
Carefully manage and dispose of waste material
Salvage and store topsoil and native plant materials
Consider location/reclamation of construction areas

2.1 Construction Aspect

In the aspect of construction, especially on the innovation of the use of pavement materials are sustainable and environmentally sound. There are several kinds of use of natural materials or waste materials as a mixture of bituminous in order to reduce the use of asphalt from petroleum.

There are several studies of the use of natural or waste materials that can be used as a substitute or reduce the use of asphalt such as bio-asphalt, coconut shell distillation results, and plastic waste. Bio-asphalt can be used instead of asphalt or reduce the use of asphalt while the distillation of coconut shell and plastic waste is only used as a reduction in the use of asphalt.

2.2 Bio-Asphalt

Bio-asphalt is derived from algae wild plants that are commonly found in swamps so often only damage the natural landscape so it will be cleaned up and thrown away as seen in Figure 1. Utilization of algae as bio-asphalt introduced by Ted Slaghek on his paper "the concept of the road based lignin "presented at the annual meeting of the American Chemical Society.



Figure 1: Algae Wild Plant.

Lignin from algae has a complicated chemical formula that has a function to make plants stand firmly, for example, corn plants have small stems but are capable of sustaining a considerable amount of corn (Market and Study n.d.). Microalgae liquefaction is processed by hydrothermal technology ie pressurized water (in critical condition). The process to date still achieves a conversion efficiency of 55% and will be increased to 100%.

Although bio-asphalt has a different chemical arrangement with asphalt, it has many similarities or close to oil asphalt composition ie black, viscoelastic and temperature as shown in table 2.

Table 2: Bio-asphalt vs. Asphalt Specification.

Specification	Bio-asphalt	Asphalt
Ductility	>120 cm	>100 cm
Viscoelastic	-20°C – 60°C	-40°C – 40°C
Temperature	212°F	200 °F

2.3 Coconut Shell Distillation Tar

Tar from the distillation of coconut shell is a process of pyrolysis of coconut shell processing which produces liquid smoke and charcoal. Liquid smoke re-processed the distillation process which later produces a more complex liquid smoke commonly used as a food preservative and tar. While the charcoal produced will be used for the manufacture of coconut shell briquettes. Usually, the process uses a simple machine as shown in Figure 2.



Figure 2: Distillation Engineering Phase I.

Tar distillation of coconut shell has physical properties such as asphalt derived from petroleum and the opportunity as a substitute for asphalt but has characteristics that are less good as a binder. Some research done by adding additive materials to coconut shell tar in the effort as a substitute of asphalt, one of them with the addition of asbuton emulsion

from research result got that material can not be used as binder (Sarwono, Legowo, and Raspati 2015). Correlation of research result can be seen in table 3.

Other studies using the type of oil palm also get the same results with ordinary coconut shell tar. So tar distillation of coconut shell is only used as material to reduce the use of asphalt from petroleum.

Table 3: Correlation of Research Result.

Type of Testing	Correlation		Term
	+	-	
Penetration Value		✓	
Ductility	✓		Below
Pointing Point Value		✓	Below
Flash Point and Burn Point		✓	Below
Material Type Weight	✓		Above

2.4 Plastic Roads

Street plastic was introduced by Prof. Dr. R. Vasudevan from Thiyagaraja College of Engineering, Madurai some 15 years ago. Roads built by used plastics, known as Plastic Roads, are better than those built with conventional asphalt, but from the results of previous research it was found that the addition of plastic waste on asphalt is only 5% which will increase the stability of asphalt and its durability 40% and when added 10% stability and resistance will decrease (Limbah Plastik Digunakan untuk Aspal Jalan, Ternyata Berisiko. Kenapa? : Mongabay.co.id n.d.).

Other studies have shown that to achieve optimum the plastic waste content added to the conventional asphalt is 8% as shown in figure 4 (Plastics and Bindermodifier n.d.).

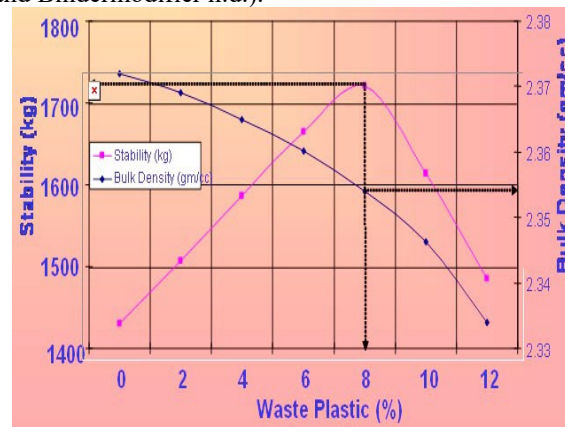


Figure 4: Optimum Waste Plastic Content.

In Indonesia, plastic roads have been piloted at Udayana University as a pilot of a plastic road project from the Ministry of Public Works and People's Housing (PUPR). Figure 5.



Figure 5: Plastic waste was tested as a mixture of asphalt for roads at the Udayana University campus, Jimbaran, Badung, Bali on Saturday (29/07/2017).

Photo: Public Communication Bureau of the Ministry of PUPR

Based on guides from the Indian road congress there are several types of plastics that are allowed for use on road pavement, Low-Density Polyethylene (LDPE), High-Density Polyethylene (HDPE), PET and Polyurethane. Having a thickness of 60 microns and associated toxic exposure then only allowed to be heated to a maximum temperature of 160 degrees Celsius only. Besides, plastic roads also have impacts, advantages, and disadvantages as shown in the SWOT analysis (table 4).

Table 4: Plastic Road SWOT Analysis.

Strength	Weakness
<ul style="list-style-type: none"> ➤ Use a higher percentage of plastic waste. ➤ Reduce the need for asphalt about 10%. ➤ Improve road strength and performance. ➤ Can reduce the cost of around IDR 10 million /km. from a single track path 	<ul style="list-style-type: none"> ➤ Toxic present in the plastic mixed with waste will begin to be washed. ➤ The presence of chlorine will surely occur releasing dangerous HCL gas.
Opportunity	Threat
<ul style="list-style-type: none"> ➤ Develop a technology, which is eco-friendly. 	<ul style="list-style-type: none"> ➤ Environmental pollution ➤ Toxic Micro Particles ➤ The Threat to Human Health

2.5 Economic and Legal Aspect

Judging from the above description, the three materials can economically provide incentives to the construction service actors as well as the role of the success of the Indonesian government program in the context of environmentally sustainable development.

Assuming the area of 2000 m² road and 5 centimeters thick and bulk density of 2.3 ton/m³, we get 230 ton of asphalt need. If the price of asphalt 1 million / ton then by reducing the asphalt with each material got cost as shown in table 5 (Gawande 2013).

Table 5: Asphalt Costs by Type of Reduction Material

Reduction Material	Prices of Technology	Cost of Asphalt
Bio-asphalt	High	135 million

Coconut Shell Distillation	Medium	150 million
Plastic waste	Low	200 million

Although the use of plastic waste in the asphalt mixture still has a considerable cost but have a price cheaper technology than the bio-asphalt and distilled coconut shell, so that they provide incentives to the perpetrators of the construction services.

Implementation of legal aspects in Indonesia on the implementation of green construction is shown in table 6.

Table 6: Implementation of Legal Aspects of Green Construction in Indonesia.

Criteria Legal Aspect of Implementation	H	M	L
Build for the long-term	✓		
Schedule construction to minimize impacts		✓	
Consider the overall energy use of a project			✓
Emphasize reuse and recycling		✓	
Clear the site only within the limits of construction			✓
Protect important environmental, landscape, and cultural features		✓	
Coordinate with construction personnel when planning and designing projects		✓	
Ensure that erosion and sedimentation are controlled during construction			✓
Carefully manage and dispose of waste material			✓
Salvage and store topsoil and native plant materials		✓	
Consider location/reclamation of construction areas			✓

3 CONCLUSIONS

Selection of materials that can reduce the use of asphalt from oil and renewable plastic waste should be used with the right percentage so that in addition to reducing plastic waste pollution and can provide economic value (cheap), also can be justified by law or rules that apply in Indonesia.

For bio-asphalt and coconut shell distillation still need refinement of its manufacture technology that can produce material with cheaper, so that can be used as a substitute for asphalt from petroleum.

BIOGRAPHIES

Arthur Daniel Limantara

PhD and Lecturer of Department of Informatics Engineering, STT Cahaya Surya, Perintis Kemerdekaan 36A, Kediri, East java, Indonesia

arthur.limantara@gmail.com

Edy Gardjito

PhD and Lecturer of Department of Civil Engineering, Kadiri University, Selomangleng 1, Kediri, East Java, Indonesia

edi_gardjito@unik-kediri.ac.id

Bambang Subiyanto

PhD and Lecturer of Department of Civil Engineering, Kadiri University, Selomangleng 1, Kediri, East Java, Indonesia

bambang_subiyanto@unik-kediri.ac.id

Fauzie Nursandah

PhD and Lecturer of Department of Civil Engineering, Kadiri University, Selomangleng 1, Kediri, East Java, Indonesia

fauzie_nursandah@unik-kediri.ac.id

Adisty Riska Hardianti

PhD and Lecturer of Department of Economic, Kadiri University, Selomangleng 1, Kediri, East Java, Indonesia

adisty_riska@unik-kediri.ac.id

Hery Lilik Sudarmanto

PhD and Lecturer of Department of Law, Kadiri University, Selomangleng 1, Kediri, East Java, Indonesia

hery_lilik@unik-kediri.ac.id

REFERENCES

“Bio-Asphalt Made from Algae Is the Future of Green Roads.” January 20, 2018.

<https://www.forconstructionpros.com/asphalt/article/12069524/bioasphalt-made-from-algae-is-the-future-of-green-roads>.

Gawande, Amit P. 2013. “Economics and Viability of Plastic Road : A Review.” 3(4): 231–42.

“Limbah Plastik Digunakan Untuk Aspal Jalan, Ternyata Berisiko. Kenapa? : Mongabay.co.id.”

<http://www.mongabay.co.id/2017/08/02/limbah-plastik-digunakan-untuk-aspal-jalan-ternyata-berisiko-kenapa/> (January 21, 2018).

Mustofa, S., Putri, E. E., Sipil, M. T., & Andalas, U. 2017. Green Road Construction (Studi Kasus: Provinsi Sumatera Barat), November, 127–136.

Plastics, Waste, and A S Bindermodifier. “Utilisation of Waste Plastic in Bituminous Mixes for Road Construction.” : 1–26.

Sarwono, Djoko, Slamet Jauhari Legowo, and Aan Raspati. 2015. “Karakteristik Tar Hasil Destilasi Tempurung Kelapa Dengan Modifikasi Penambahan Asbuton Emulsi Ditinjau Dari Spesifikasi Aspal Produk Pertamina.” *Matriks Teknik Sipil* 3(3): 663–69. <http://sipil.ft.uns.ac.id/ojsin/index.php/MaTekSi/article/view/380>.

Sipes, James L., and Matthew L. Sipes. 2013. Creating Green Roadways, Chapter 10-12, page 211-263, <http://link.springer.com/10.5822/978-1-59726-322-1>.