A BREAKTHROUGH IN ASPHALT TECHNOLOGY - CHEAPER BITUMEN EXTRACTED FROM "ASBUTON", THE ROCK ASPHALT OF BUTON ISLAND, INDONESIA.

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Abstract

The Island of Buton in south-east of Sulawesi, Indonesia, has been known to have a significant natural reserve of rock asphalt, which is known as Asphalt of Buton (or better known as "Asbuton") or also Buton Asphalt ("Butas"), such that this reserve may guarantee at least of about 100 years supply of bitumen for Indonesia. This Asbuton rock asphalt, however, has not been used very widely in Indonesia, because of many difficulties found during applications, and especially because of the costs of using Asbuton materials are always much higher than those using common petroleum asphalt for high-quality pavement materials. Researchers of Asbuton mostly agree that pure bitumen should be separated from its minerals of Asbuton, in order for the bitumen to be used widely and economically, so that Asbuton could replace the country dependency on imported petroleum bitumen.

Many efforts have been tried to separate bitumen Asbuton from its minerals, but the methods were so far still unsatisfactory due to the higher cost of the bitumen produced. A breaktrough was obtained by a team of researchers from Institut Teknologi Sepuluh Nopember, ITS, of Surabaya, Indonesia, in 2013. This team has been successful in extracting purified bitumen, almost 99% pure bitumen, from Asbuton with results of costs comparable or lower than that of petroleum bitumen. The first attempt was to use kerosene as the dissolving agent, and the results are given in this paper that also includes the methods of bitumen extraction and the estimated price of bitumen produced. The smaller amount of kerosene lost during the process, the lower the cost of bitumen produced; so that it is very possible to produce pure bitumen from Asbuton with comparable or lower cost than that of petroleum bitumen. The more significant breakthrough, however, was found later in the end of 2013 and early 2014, in which water was used as the main separating agent, so that the cost of pure bitumen produced from Asbuton could be kept to merely about one third of the cost of petroleum bitumen.

Key words : bitumen extraction, rock asphalt, Asbuton, bitumen production cost, asphalt technology

A Breakthrough in Asphalt Technology – Cheaper Bitumen Extracted from "Asbuton", the Rock Asphalt of Buton Island, Indonesia.

1. Introduction.

The Buton Island of Indonesia has been known to have a large deposit of rock asphalt, in which the formations of predominantly limestone rocks are impregnated with bitumen residue of ancient petroleum deposit. The content of bitumen inside the rocks ranges from about 15% to 35% of the total weight of rocks, while the rock asphalt deposit was estimated to be at least around 670 million tons (Balitbang PU, 2012; Kurniaji and Nono, 2006; Satyana et.al. 2013). Assuming the rocks contain an average of 25% of pure bitumen, the total pure bitumen can be extracted will be around 160 million tons, a guarantee of at least 100-year supply of pure bitumen when compared to the current total national consumption of bitumen in Indonesia of about 1.5 million tons per year. Some experts believe that the Buton Island may contain more rock asphalt deposit than currently estimated . This rock asphalt of Buton Island of Indonesia is well known as "Asbuton" (**as**phalt of **Buton**), or also as "Butas" (**But**on **as**phalt). The location of Buton Island can be seen in Figure 1.

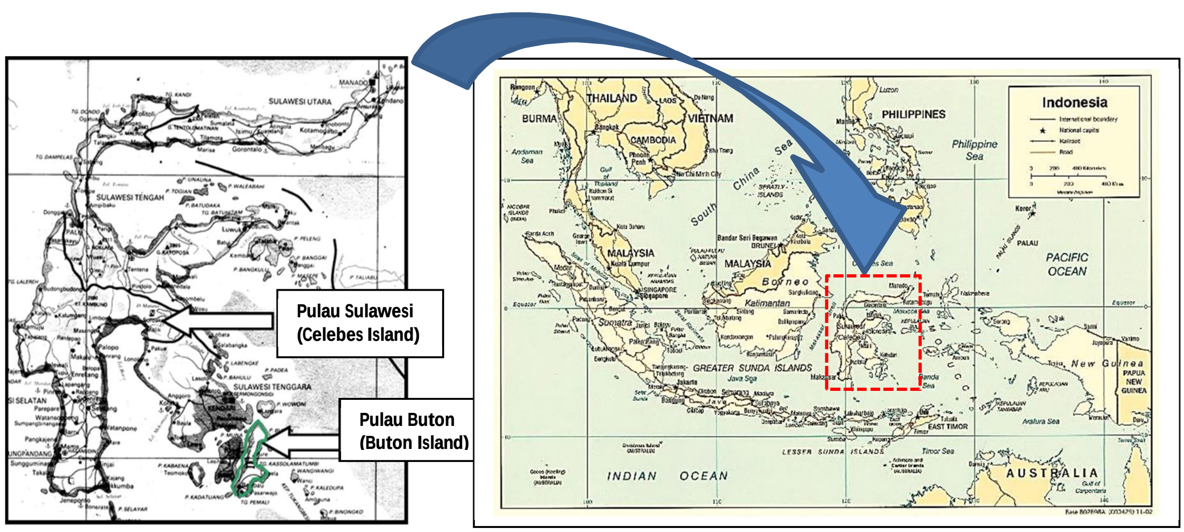

Figure 1. Location of Buton Island in south-eastern side of Pulau Sulawesi (Celebes Island) and in Indonesia.

The existing problems with using the Asbuton are mainly as follows:

1. Asbuton can not be used directly as high-quality road pavement material, it has to be mixed with new aggregates and to be added with special modifier material or petroleum bitumen. Since the price of Asbuton is considerably higher than petroleum bitumen, the results of pavement mixture using Asbuton are almost always much more expensive than those of conventional asphaltic pavement mixture of comparable quality using petroleum bitumen (Mochtar, 2003; Kurniaji, 2002; Nono and Kurniaji, 2008)
2. Attempts to use Asbuton alone as the source of bitumen for high-quality asphaltic concrete mixture for highway pavement have not been successful so far, because the existence of relatively higher percentage of non-bitumen minerals in the Asbuton. The minerals are predominantly limestone minerals, and with the particle sizes of mostly "filler" (passes # 200 sieve of ASTM Standard). The existence of the non-bitumen minerals as filler fraction limits the amount of Asbuton in the mix to small fraction only, so that petroleum bitumen is still needed as the main portion of binder. In most cases, high-quality asphalt pavement required only relatively small percentage of Asbuton, as an additive only, with higher cost than the conventional one. (Nono and Kurniaji, 2008; Affandi 2009; Wasono, 2010;).
3. The use of Asbuton also requires some modifications of mixing procedure to be performed in the Asphalt Mixing Plant, AMP. Most asphalt contractors consider this procedure unnecessary and cumbersome, while increasing cost, too.
4. In general, people are still very reluctant to use Asbuton as pavement materials due to difficulties in obtaining high-quality asphaltic mixture and higher cost to implement.
5. Parallel with the rapid progress in economy and national road building, the demand of petroleum bitumen is very high in Indonesia, and it keeps increasing; yet, Indonesia still has to import almost all of its petroleum bitumen. This situation is ironic, since very large deposit of bitumen material is available in Buton Island but practically nobody demands it.

The key for Asbuton to be able to replace the use of petroleum bitumen in Indonesia is when the price of Asbuton to become cheaper than that of petroleum bitumen, which in 2014 the petroleum bitumen is sold around Rp 10,000. per kg, or slightly less than USD 1.00/kg. To achieve this, many Asbuton researchers believe that the following conditions should prevail first (Mochtar, 2009):

a. Bitumen in more purified form should be extracted from Asbuton, and most of the minerals of Asbuton should be discarded. Therefore, the use of purified bitumen will be similar to those of petroleum bitumen, so that no modification in AMP (Asphalt Mixing Plant) is necessary.
b. To minimize cost, bitumen factory should be built in Buton Island, so that transportation cost is minimum, since it is for transporting pure bitumen only.
c. The selling price of purified bitumen from Asbuton should be equal to or less than that of petroleum bitumen.

Untill 2012, many efforts have been performed to find the most economical ways to extract bitumen from Asbuton. A breaktrough was obtained by a team of researchers from Institut Teknologi Sepuluh Nopember, ITS, of Surabaya, Indonesia. This team has been successful in extracting purified bitumen, almost 99% pure bitumen, from Asbuton with results of costs much lower than that of petroleum bitumen. This paper is to describe the methodology in general of such processes and to give the estimated price of such bitumen production (Halimi, Mochtar, and Altway, 2014).

2. General Methods of Bitumen Extraction from Asbuton

The methods to extract bitumen from Asbuton in general follows two principles, which are:
1. To separate the bitumen from its minerals by means of solvent materials, commonly used are the fluxing oils such as kerosene, naphta, gasoline, or even solar/diesel oil (Halimi, et.al. 2014).
2. To mix the bitumen with chemical agents that react with the minerals, i.e. certain acidic solution will react with the limestone mineral, etc., so that the minerals are separated from the bitumen (Sayono, 2000; Budianta and Nasikin, 2012).

The use of chemical agents to react with the minerals was found to be much more expensive and difficult to control the product, since certain chemical agents reacted to a particular mineral only, while usually about 15 – 20% of the minerals were not limestone. Besides, some acid compounds chosen was also reactive with the metal equipment used in the process.

In the study by team researchers of ITS (Halimi et.al., 2014), efforts had been conducted to flux bitumen from Asbuton using Gasoline, Kerosene, and Diesel Oil/Solar. The solvent oils will gradually separate the bitumen from the solid parts of the Asbuton minerals. The bitumen would dissolve into the solution, while the minerals would settle into the bottom of the tank. The actual cost of the process was very much determined by the amount of the solvent materials that could be recaptured and reused in the process. As much as possible the solvent material should be recaptured from the two separated parts of Asbuton, which were: 1. from the mixture of solvent oil and bitumen, and 2. from the mixture of solvent oil with the remaining solid minerals. Failure to recapture and recycle the solvent material from the Asbuton mixtures may cause considerable increase in the cost of Asbuton extraction process.

Using Gasoline, which had boiling point between 60° - 100°C, lower extraction efficiency was found in separation of bitumen from its Asbuton minerals, when compared with that of kerosene and diesel oil. However, separation between the gasoline and the dissolved bitumen were faster and easier by means of rapid evaporation of the Gasoline. The main drawback with using Gasoline was that this material was very dangerous to work with since it was highly volatile and could easily cause explosion or fire, so that extreme cautious was required at all times.

Kerosene, with boiling point between 180° - 250°C, had higher extracting power than gasoline and it was much safer to work with. Explosion was not likely to occur, yet fire eruption might be possible if the temperature was let become very high. The shortcoming with kerosene was that it took longer time to recapture the kerosene from the bitumen-kerosene solution. Considerable effort was required in recapturing kerosene from the kerosene-bitumen solution, mostly by means of distillation process. To recapture kerosene from minerals was done in several repetitions of washing (with water) and distillation processes, such as to be described in the later sections of this paper.

The use of diesel oil was almost as effective as kerosene in extracting bitumen from Asbuton, since the diesel oil had higher boiling point between 250° - 300°C. This method was in generally also much safer and hardly likely to cause any fire hazard. However, the use of diesel oil during the process had cause production of very strong and very disturbing odor to most of the operators, so that many people would oppose to the smelly odor. Furthermore, recapturing the solvent from bitumen-solvent solution was more time consuming and more difficult than those with kerosene. Therefore, considering all the conditions above, kerosene has become the most likeable solvent for such bitumen extraction process. Other types of solvents were not attempted, considering their much higher prices than kerosene.

3. Processes and Cost of Extracting Bitumen from Asbuton Using Kerosene as Solvent (Halimi, et. al. 2014)

The general diagram of bitumen extraction could be seen in Figure 2. In Stage 1, raw Asbuton was first made into several fractions of sand gradations: 1). fraction between sieves # 8 and # 16; 2). fraction between sieves # 16 and # 30; and 3). fraction between sieves # 30 and # 50. The smaller fraction in general had given the best results in extraction process. The granulated Asbuton was then mixed with kerosene of certain proportion of mixture, and this is the end of Stage-1 process.

In Stage-2 process, the extraction of bitumen with kerosene was performed inside a centrifuge so that liquid solution was separated from the solid mineral solution. The liquid solution would contain mostly of mixture of bitumen and kerosene, while the solid mineral solution obtained from this process contained mostly wet minerals with some kerosene and remaining bitumen. In these processes, as much bitumen as possible should be separated from its minerals, so that the final products of this Stage-2 were bitumen-kerosene solution and minerals-kerosene mixture.

The next process in Stage-3 was to separate the bitumen from its liquid solvent of kerosene using distillation method, while trying also to recapture back kerosene as much as possible form the mineral-kerosene mixture. This Stage-3 is the most costly of process, especially in the relatively slow process of distillation to separate the kerosene from the bitumen-kerosene solution. As much as possible of kerosene should be recaptured from this process to be reused. These processes in Stage -3 hold the key for the overall cost of bitumen produced. When distillation process was not done properly, some kerosene would still remain in the bitumen, causing the final bitumen product to become softer and not meeting the criteria of high-quality bitumen. Whereas, when some kerosene were still left inside the minerals – kerosene mixture, the lost kerosene would become significant, so that the price of producing pure bitumen would become too high. It should be noted here, that the minerals comprise of 60 to 80% of all Asbuton material, so that even only a small fraction of kerosene left in the mineral-kerosene mixture would contribute significant lost of kerosene in the overall process; and therefore, considerable increase of the production cost.

The cost of producing pure bitumen (about 98% purity) from Asbuton had been calculated and given by Halimi et. al (2014) and it could be seen in Figure 3. It should be noted that the price of solvent, which in this case was kerosene, will be a very significant factor in determining the overall cost of producing the pure bitumen. In Figure 3, it is apparent the cost of producing pure bitumen will depend very much on the Asbuton grades (B-20, B-30, or B-40; in which 20, 30, 40 are the average percentages of bitumen in the Asbuton natural forms) and the amount of total kerosene lost (could not be recaptured) during the process of purifying the bitumen.

From Figure 3, for example one can estimate the cost of producing pure bitumen from Asbuton with total lost of kerosene of 5% is about Rp. 11,600. per kg. using Asbuton grade B-20; yet it is merely Rp. 7,800. per kg. using Asbuton grade B-30, and it is Rp. 5,800. per kg. using Asbuton grade B-40. Whereas, if the total lost of Asbuton is merely 4%, the costs per kg. bitumen are Rp 10,300 ; Rp. 6,800 ; and Rp. 5,100, for B-20, B-30, and B-40 grades of Asbuton, respectively. Therefore, using higher grades of Asbuton is more cost effective, and the total amount of solvent lost during the process is very crucial to the total cost of pure bitumen production.

During the laboratory trial by Halimi (Halimi et. al. 2014), the lowest amount of kerosene lost in the process was about 3%, so that this process is considered very promising . However, to obtain as much profit on production, the use of higher grade than Asbuton B-20 is recommended. To be competitive, the selling price of pure bitumen of Asbuton should be comparable with that of petroleum bitumen. While the final price is still very much depended on the difference between the price of kerosene and the price of petroleum bitumen, it is however concluded that production of relatively cheap pure bitumen from Asbuton is entirely feasible.

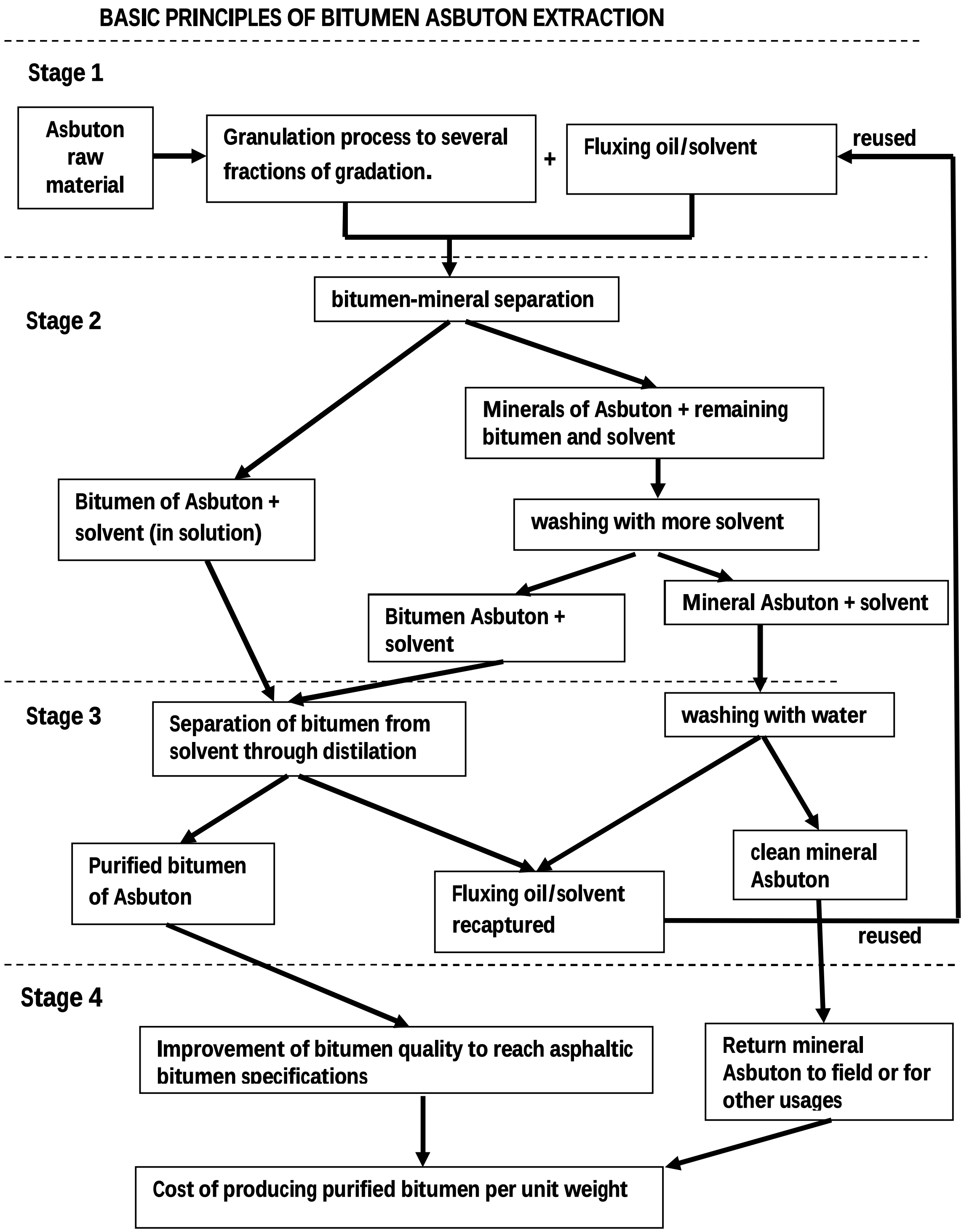

Figure 2. Basic principles of bitumen Asbuton extraction (from Halimi et. al.

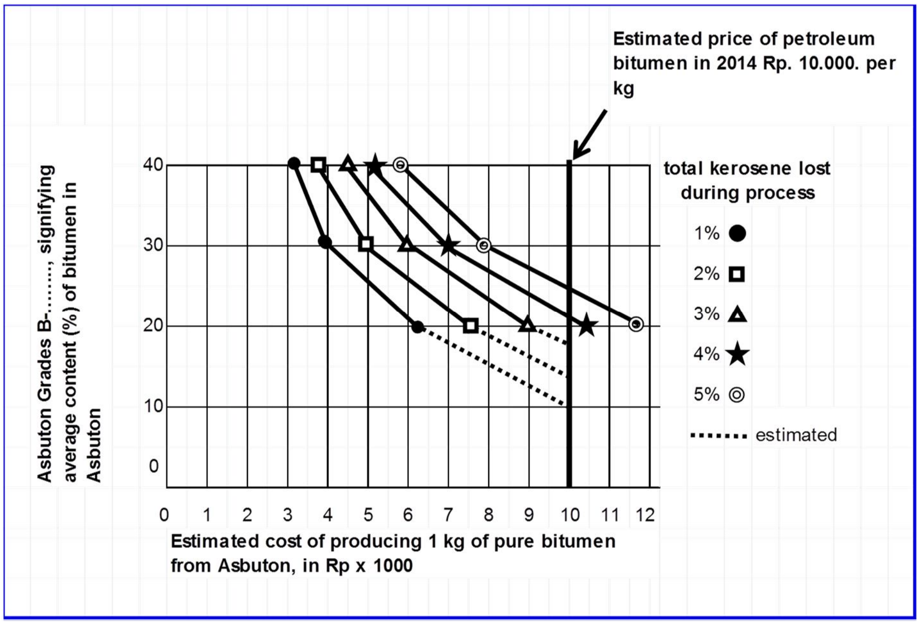

Figure 3. Estimated cost of producing pure bitumen from Asbuton using method of Halimi et. al. (2014)

4. Recently Most Signficant Breakthrough

A major breakthrough was recently obtained by the team of researchers of ITS on Asbuton at the end of 2013 to early of 2014. A slight modification of the process was performed and the solvent used was mostly water. This method was actualy an improvement of previous results by Sidiq et. al. (2013). The Asbuton team of researchers had successfully created a special liquid to be used just to soften the Asbuton and afterwards to use mostly only water to separate the bitumen from the minerals of Asbuton. This method had been found to give very considerable saving in production cost, so that an early estimate for the cost of producing pure bitumen was only about Rp 3,500 per kg. of pure bitumen. This represents very significant profit for the producer, while relatively very small amount of kerosene or other petroleum-based solvent are used during the process. This process, however, could not be revealed here because it is still in the process of being patented.

As the follow up of the proceeding researches, a pilot plant project had been constructed in ITS to simulate a miniature Asbuton bitumen factory, using the most recent technology. With this pilot plant project, the actual equipments needed for the Asbuton factory can be established, so that the amount of major investment needed to build a real bitumen factory in the Island of Buton can be calculated. The pilot plant project was already completed in March 2014, and trial runs and production simulations are currently in progress.

5. Conclusion:

The conclusion of the above information are:

1. Indonesia should not depend on imported foreign bitumen any longer, since the amount of Asbuton in Buton Island is relatively very abundant to maintain production of about 1.5 million tons of pure bitumen every year, for approximately 100 years
2. It is entirely feasible to produce pure bitumen from Asbuton, using the most recent technology mentioned in this paper, with the bitumen price to be very competitive to that of the petroleum bitumen, while still maintaining a good profit from the production.
3. The higher grade of Asbuton used will result cheaper production cost and higher profit margin.

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