# BUTUR SEAL AS AN ALTERNATIVE LOW TRAFFIC PAVED ROAD

*H. R. Anwar Yamin*, Ketut Dharsana*, Imam Aschuri***

*Institute of Road Engineering, Agency for Research and Development, Ministry of Public Works

*** Department of Civil Engineering, National Institute of Technologi (Itenas), Bandung*

H. R. Anwar Yamin
Pusat Litbang Jalan dan Jembatan
Jl. A. H. Nasution 264 Bandung 40294
E-mail : aypto@yahoo.com

Ketut Dharsana
Pusat Litbang Jalan dan Jembatan
Jl. A. H. Nasution 264 Bandung 40294
E-mail : ketdharsana@yahoo.com

Imam Aschuri
*Department of Civil Engineering, National Institute of Technology (Itenas), Bandung* 40294
E-mail : Aschuri@yahoo.com

***Abstrak***

*Perkembangan dan kondisi infrastruktur khususnya jalan sangat menentukan perkembangan dan aksesibilitas suatu daerah. Pada daerah yang sedang tumbuh berkembang seperti kabupaten Buton Utara dimana lalu lintas harian kendaraan tidak begitu berat dan padat, pembangunan jalan yang sesuai dengan jenis dan syarat spesifikasi Umum Bina Marga yang ada saat ini agak sulit dilakukan dan dipandang kurang tepat untuk diterapkan. Jalan poros selatan-utara pulau Buton adalah jalan utama satu-satunya yang menghubungan kabupaten Buton dengan kabupaten Buton Utara, yang tiap harinya melayani lalu lintas kurang dari 100 kendaraan. Berdasarkan volume lalu lintas yang dilayaninya, tipe jalan yang cocok adalah jalan tanah, tetapi karena sebagian besar ruas jalan ini melintasi hutan belantara yang sangat lebat dan terletak pada daerah dengan kelembaban yang yang tinggi sehingga jalan tanah akan cepat sekali mengalami kerusakan. Oleh sebab itu, pemilihan jalan dengan laburan (seal), yaitu Lapis Penetrasi MacAdam, chip seal, cape seal ataupun otta seal adalah alternatif jenis jalan yang dapat pilih. Namun karena sulitnya mendapatkan agregat standar dan agregat pecah, tipe-tipe jalan inipun sulit dan kurang ekonomis untuk diterapkan di pulau Buton khususnya di kabupaten Buton Utara. Butur seal adalah singkatan dari Buton Utara seal yang telah dikembangkan sejak tahun 2008. Konstruksi butur seal dibuat dengan menggunakan agregat lokal (substandard) ukuran maksimum 3 inch dengan tanpa memperhatikan gradasinya dan asbuton butir sebagai pengikat pada bagian atasnya. Tulisan ini bertujuan untuk mengevaluasi kinerja butur seal pada jalan poros selatan-utara pulau Buton yang telah melayani lalu lintas sejak tahun 2008, 2009 dan 2010. Selain itu juga bertujuan untuk menentukan jenis dan proporsi asbuton yang dapat digunakan dalam pembuatannya. Dari tulisan ini didapat disimpulkan bahwa butur seal setebal 17 cm dengan menggunakan asbuton butir B50/30 sebagai lapis penutup dapat dijadikan sebagai alternatif teknologi jalan berpenutup untuk lalu lintas rendah (low volume paved road).*

***Kata Kunci*** *: Agregat lokal substandar, asbuton butir, butur seal, Buton Utara*

***Abstract***

*The development and condition of infrastructure, particularly roads and accessibility will determine the development of an area. In the growing areas like North Buton district where daily traffic is not so high and heavy, construction of road in accordance with the types and Bina Marga's currently specifications is rather difficult and is seen as less appropriate to be*

*applied. South-north road corridor of Buton island is the only one main road which is conect district of Buton and North Buton. This road serves daily traffic of less than 100 vehicles. Based on the volume of traffic served, the type of road suited to that is a dirt road, but because this road mainly through a very dense jungle and are located in areas with high humidity so that the dirt road will be quickly damaged. Therefore, the selection of the seal road, such as penetration MacAdam, chip seal, cape seal or otta seal are alternative types of road that can be chosen. However, due to the difficulty of getting a standard and crushing aggregate, even these road are difficult and less economical to construct. Butur seal is the abbreviation of North Buton seals that have been developed since 2008. Butur seal is made using local aggregate (substandard) with 3-inch maximum size regardless of the gradation and grained asbuton as a binder at the top. This paper aims to evaluate the performance of butur seal on the south-north road corridor of Buton island which have been opened to traffic since 2008, 2009 and 2010. It also aims to determine the type and proportion grained asbuton that can be used for that. It can be concluded from this paper that 17 cm of butur seals with grained asbuton of B50/30 as a topping layer can be used as an alternative technology of low volume paved roads.*

*Keywords : Substandard local agregate, grain asbuton, butur seal, North Buton*

## I. BACKGROUND

The development and condition of infrastructure, particularly roads and accessibility will determine the development of an area. The accessibility and economic development of a region is strongly influenced by the availability and road conditions. Road construction should be able to accommodate the traffic load and not susceptible to environmental influences. Therefore, in the general specifications of Bina Marga, type of construction and properties of the materials used in road pavement are required and must be must be met interm of performance and durability.

In the growing areas like North Buton district where daily traffic is not so high and heavy, road construction based on Bina Marga's currently specifications is rather difficult to be applied. This is due to some reasons, the first is the limited budget in road construction, and the second is type of paved road in Bina Marga's the specification is over design to accommodate the existing traffic in this area.

South-north road corridor of Buton island is the only one main road which is connected to district of Buton and North Buton. This road accomodate daily traffic of less than 100 vehicles. According to Yamin (2010), based on the traffic volume, the suitable type of road is a unpaved road. But noted that corridor Buton road located in areas with high humidity, the selection of unpaved roads is not appropriate, because unpaved road is very sensitive to water and can not be built by using soil that has a high plasticity values. In Figure 1 is shown the condition of unpaved roads on the Buton island which only as a corridor of Buton connected district of Buton and North Buton.

For low traffic conditions and the environment with humidity and high rainfall, the selection of the road using seal, i.e Layer of MacAdam's Penetration, chip seal, cape seal or otta seal is an alternative of paved road type. However, the aplication of MacAdam's Penetration layer (LPMA) requires good quality of coarse aggregate and fine aggregate, meanwhile chip seal and cape seal require the use of single size aggregate with excellent quality and quite

modern equipment. These types of road are less economical to be applied on the Buton island because of some reasons such as the lack of availability of aggregate that meets the desired requirements and lack of availability of equipment for asphalt distributor and chip spreader. The otta seal requires aggregate used in road pavement is not strict as chip seal requirements, however the gradation of aggregate must be fulfillment of the required gradation and this job need the use of asphalt distributor. The lack of availability of a stone crusher is one of problems to apply LPMA, chip seal, cape seal or otta seal on Buton island.

Figure 1. Road Condition of Unpaved Road on North-South Corridor of Buton Island

Resulting from these problems and the needs for good road conditions, in 2008 perfomed breakthrough by modifying and collaborating LPMA, otta seal and cape seal become a new type of seal named as butur seal. Butur seal is abbreviation of '*Buton Utara* seal'. Construction butur seal made using local aggregate (substandard) with 3-inch maximum size with regargless the gradation, compacted, given asbuton grained and key aggregates then recompacted. To provide a good initial bound, prior to spreading grained asbuton over a layer of dense aggregate, initial bound by using liquid asphalt or asphalt emulsion must be applied first.

This objective this paper is to evaluate the performance butur seal on the south-north corridor road of Buton island which was built in 2008, 2009 and 2010 and to determine the type and asbuton proportion that can be used in road construction. Expected by this studi taht the Butur seal can be used as an alternative technology of paved Road for low traffic volume.

## II. REFERENCES

### 2.1. MacAdam's Penetration

MacAdam's Penetration (LPMA) is the layer that made by using the main aggregate with a relatively uniform gradation and key aggregate. Before spreading key aggregate, main aggregate should be spread out with a thickness is approximately twice of the largest aggregate size and compacted by vibrating roller that obtained 75% thicker than uncompacted thickness. Then asphalt is spread on top of aggregate and then spread out key aggregate and compacted again by using vibrating roller and continued by tyred roller that resulting strong and quite impermeable LPMA. LPMA very effectively used on road that serve a daily traffic volume between 25-400 vehicles per day (Yamin, 2010).

Dharsana (2010) attempt a further development of the LPMA by introducing the LPMA - Asbuton (LPMAA). This development is only focused on the use of grained asbuton as a substitute asphalt as a binder in LMPA. LPMAA made using compacted main aggregate that given grained asbuton B50/30 on the top of it, key aggregate and be continued with provision of grained asbuton B50/30 and compacted. Before spread out grained asbuton on the compacted of main aggregate layer, a initial bounding apllied first using a liquid asphalt or asphalt emulsion first, as well as on the lock aggregate. The objective of initial bound is to assist the formation of good bound between the aggregate with grained asbuton. Based on experiments (Dharsana, 2010), good LPMAA (Figure 2) can be produced by using 0.3 kg/m2 of the initial bound (residue) on the main aggregate and 0.2 kg/m2 on the key aggregate. Meanwhile for grained asbuton B50/30 can be spread out on main aggregate is about 10 kg/m2 and 12 kg/m2 for key aggregate.

Figure 2. LPMAA after One Year Asbuton in Service

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### 2.2. Chip Seal

Chip seal is a layer of asphalt followed by adding a single layer of chipping (Figure 3). Providing asphalt and chipping can be done several times times with techniques and suits chip size with desired type of chip seal. The use of chip seals is to give a cover layer in foundation layer and providing a durabe layer I with adequate slip resistance in the asphalt layer (Edmund, 2008). In some countries, chip seal is also known as surface treatment, surface dressing or spray seal. In Indonesia, in the Bina Marga's General Specifications (DPU, 2007), the kind of works that it can be categorized as chip seal are *Burtu* and *Burda*.

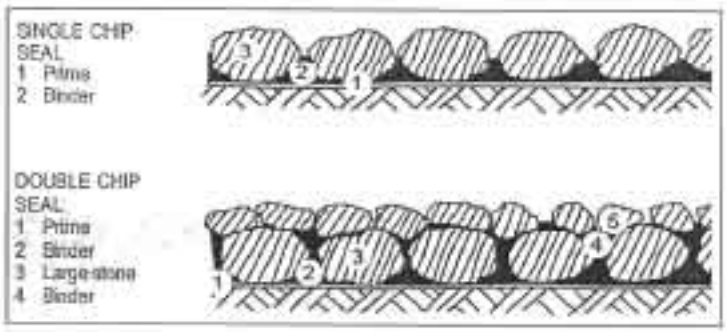


Figure 3. Illustration of Single and Double Chip Seal

For chip seal, typical size of the chips that are used commonly is 7, 10, 14, 16 and 20 mm. For double chip seal, comparison of first and second chip size normally is 1 : 2. Chip spread directly above the road pavement without or with precoating (precoating chips) first by using 1.0% - 1.75% asphalt emulsion (Yamin, 2009). Whereas type of asphalt used can be either ordinary asphalt, Polymer Modified Bitumen (PMB) or Polymer Modified Emulsion (PME). Some of the additives can also be used to enhance the adhesion like amine, diamine, megamine or lelamine.

Chip seals can be used as a cover layer on foundation layer either in the form gravel base, crushed base, cemented base or substandard natural base (Walter, 2008). According to Lance (2008), one of the fundamental factors that determine the success of chip seal that spread on top of unbound foundation layer is strength and stability of the foundation layer itself. If the chip seal will be installed on top of unbound foundation layers, to produce a good performance, the density of the foundation layer must reach 102% density of standard laboratory (Bruce, 2008).

### 2.3. Cape Seal

The further development of the chip seal is a cape seal as shown in Figure 4. Cape seal is a chip seal combined with the slurry seal. Cape seal was first developed in South Africa and now are widely used in Australia and USA. Cape seal is a layer of slurry on a single chip seal work. Slurry can be appled after 2 or 3 days of the chip seal work was completed. The purpose of the slurry distribution is to improve the chip seal performance where the presence of this slurry, the aggregate (chip) in chip seal will be more strongly attached, increase the impermeability layer of chip seal and besides that the performance, durability and appearance of the chip seal will also exhibit better. It should be noted that in cape seal, chip seal and slurry seal is a whole layer that should not be separated from one another and durability of the cape seal is determined by the slurry and the materials used in the manufacture of slurry. (Clauton, 2004).

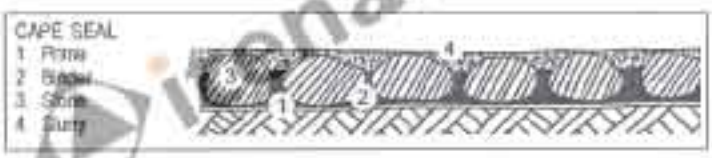


Figure 4. Illustration Cape Seal

Cape seal can be used in area when slurry seal can not repair the damage of rutting or corrugation on the existing road. According to Cambell (1977), the use of cape seal for roads that serve the heavy traffic with 500 vehicles / lane / day gave a good performance up to the age between 7-10 years. The Damages commonly occur in cape seal are bleeding and shoving, other damages such as cracking and rutting are rarely found on the cape seal (Mansour et al. 1998).

### 2.4. Otta Seal

Another type of seal that effective in terms of cost and it can be used for all conditions is the otta seal. Otta seal as shown Figure 5 is one of the types of seals that made using continuously graded aggregate, open graded and low viscosity asphalt with greater quantity and compacted (Charles, 1999). As a result of process of compaction and traffic, asphalt will move up and binding the aggregate. With resulting the strength of the otta seal will be generated by asphalt ability to bind the aggregate and interlocking between the aggregates themselves. This is the main basic different between otta seal with a chip seal, where the

strength of the chip seal is only depends on high asphalt viscosity ability to bind spread chip above.

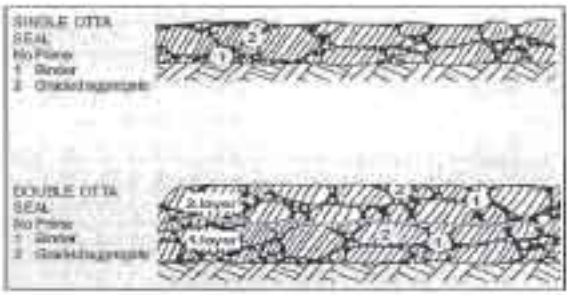


Figure 5. Illustration of Single and Double Otta Seal

Otta seal may be placed on top of almost all type of foundation or on top of the old asphalt layer. The experience in Norway and Kenya (Charles, 1999) shown that the Otta seal still give satisfactory performance when placed in the top layers of old asphalt with Bengklemen Beam deflection values above 1.25 mm.

Otta seals can provide good performance even though using lower quality aggregates, either in terms of shape, strength, texture or material with a high content of fine particles (IP <10). However, otta seal will provide the best performance when used aggregate containing at least 30% crushing of non-plastic aggregates.

To get a good bound, asphalt that used for otta seals must have low viscosity, i.e asphalt pen 200, MC-800 or MC-3000. Liquid asphalt of SC type may not be used for the otta seal, because it has curring process takes a long time. Asphalt emulsion is also should not be used because it is too liquid, so it tends to draine off when used with a lot of quantity.

Compaction of otta seal must be done using Tyre Roller (TR) with minimum of 15 cycles. Compaction is continued with a tandem minimum of 1 cycle. Compaction of the TR should be continued as many as 15 cycles again in the next day and continued well until the day after tomorrow.

Figure 6- shows the visualization of all of pavements technologies as mentioned above such as LMPA-Asbuton (in Indonesia), chip seal (in Indonesia), cape seal (in America) and otta seal (in Botswana) that had served trafic on several years.

a. LPMA-Asbuton | b. Chip Seal | c. Cape Seal | d. Otta Seal

Figure 6. Surface Appearance of LPMA and Some Types of Coatings Seal

## III. BUTUR SEAL

Butur seal was first developed in the district of North Buton (Butur) in 2008. Butur seal is made using local aggregates as classified in substandard material as shown in Figure 7. A lot of local aggregates quarry located near road corridor. This aggregate is collected directly on site with no consideration to the gradation but it should have a maximum size of 3 inches.

In butur seal process, aggregate is spreading directly onto subgrade and then compacted with a vibrating wheel steel roller for 2 cycles, and then given grained asbuton B50/30 as much as 10 kg/m2 on top of it, then recompacted with by the same roller for 2 more cycles. Then the same asbuton as many as 12 kg/m2 spread back again and compaction continued for two more passing of the same roller and 12 cycles with tyred roller. To assist getting a good bounding between aggregate and grain asbuton, a liquid asphalt or asphalt emulsion with a specified quantity was applied on top of compacted aggregate layer before grained asbuton spread. Figure 8 shows some of the working order the manufacture of butur seal that has been done in North Buton.

Figure 7. Local Aggregates Used in Seal Butur


Figure 8. The Sequence of Main Job for Butur Seal

Until now, several roads use the butur seal as a tipe of paved road in North Buton district were Membuku-Ereke segment (2008), EelHaji – Ereke segment (2009), Wakansoro – Lagundi segment (2009), Wa Ode Buri – Lelamo segment (2010), Buranga – Ronta segment (2010), Lemo – Bonerombo segment (2010) and harbor road (2010). Butur seal performance evaluation performed after these roads serve traffic 1-3 years. From those roads, the three segments that are evaluated i.e Wa Ode roads Buri-Lelamo, EelHaji-Ereke and Membuku-Ereke. Each of these roads represent a service life of 1, 2 and 3 years.

To determine the performance and the type of damages from the three segments mentioned above, the surface condition assessment has been done visually. The main damage that occurs in segment of Wa Ode Buri-Lelamo is delamination (Figure 9.a), while in the segment of EelHaji – Ereke, the main damage is plastic deformation (Figure. 9.b) and cracks are the major damage that occurs in the Membuku-Ereke segment (Figure 9.c). Quantitatively, all types of damage that occurs in the third segment of these coridors as shown in Table 1. The dimentional of butur seal, the amount of asphalt and the use of initial bounding derived from test pits and laboratory tests were given in Table 2.

a. Wa Ode Buri-Lelamo segment (2010) b. EelHaji – Ereke segment (2009) c. Membuku-Ereke segment (2008)

Figure 9. Major Damage on The evaluated Road Segments

Table 1. Damage Types and Quantity of Butur Seal on Evaluated Road Segments

| No. | Type of Testing | Location & Testing Results | | |
|---|---|---|---|---|
| | | Wa Ode Buri-Lelamo (2010) | EelHaji –Ereke (2009) | Membuku-Ereke (2008) |
| 1 | Crack, (%) | 4.68 | 0.00 | 20.68 |
| 2 | Patches, (%) | 0.00 | 0.00 | 0.52 |
| 3 | Pot hole, (%) | 0.37 | 0.03 | 0.01 |
| 4 | Deformation, (%) | 0.00 | 0.00 | 0.00 |
| 5 | Delamination, (%) | 13.49 | 0.00 | 0.00 |
| 6 | Plastic deformation, (%) | 0.10 | 14.23 | 0.00 |
| 7 | Total areas of Damages | 18.63 | 14.26 | 21.20 |
| 8 | Total areas of Good Condition | 81.37 | 85.74 | 78.80 |

Table 2. Dimentional and Testing Results of Butur Seal on Evaluated Road Segments

| No. | Type of Testing | Location & Testing Results | | |
|---|---|---|---|---|
| | | Wa Ode Buri-Lelamo (2010) | EelHaji - Ereke (2009) | Membuku-Ereke (2008) |
| 1 | Road length, m | 3100 | 2500 | 2400 |
| 2 | Road width, m | 4.0 | 5.0 | 4.0 |
| 3 | Butur seal thickness, cm | 11.0 | 12.0 | 17.0 |
| 4 | Layer Thickness, Asbuton, cm | 1.0 | 1.5 | 1.0 |
| 5 | Asbuton weight, kg/m² | 12.0 | 24.0 | 16.0 |
| 6 | Initial bound | Tidak Ada | Sangat banyak | Memadai |
| 7 | Asbuton Bitumen content, (%) | 21.3 | 21.0 | 21.9 |
| 8 | Water levels, (%) | 3.7 | 2.0 | 0,7 |
| 9 | bitumen Penetration, 0.1mm | 71 | 39 | 21 |
| 10 | Asbuton type | B60/30* | B30/x** atau Bx/20** | B20/x** atau Bx/20 |

Note: * Does not meet the requirements of grained asbuton B50/30 Required
** Type used asbuton is unknown and can not be predicted from this study

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It cn be seen from Table 2 that the three roads were generally still in good condition (about 80%). The Damage of permanent deformation does not occur on these three roads segments. With a thickness of 17 cm of butur seal, Membuku-Ereke road is still able to provide excellent performance to serve the daily traffic of about 100 vehicles per day for 3 years without showing tend to permanent deformation. However, minor damages already started to form. More interesting that type of damage that dominantly accur on of the three roads segments is not the same.

For the Ode Buri road Wa-Lelamo segment which was conducted in 2010, the dominant damage is delamination (13.49%). From the results of inspection and testing known that spreading of grained asbuton carried on top of the layer of aggregate on roads is not preceded by the provision of initial bound, so that the bounds between grained asbuton with a surface aggregate is not so good.

Although the penetration of the asbuton bitumen used on the Ode Buri road Wa-Lelamo segment is high (71 dmm) but grained asbuton used was less (12 kg/m2 with 21.3% bitumen content). This may also a cause of less the bound between the aggregate and grained asbuton. For bitumen content of 21.3% and the using dozis of 12 kg/m2, bitumen produced only by 2.5 kg/m2. To produce a good bound, the amount of bitumen is needed is 5 kg, so for bitumen content and the quantity of grained asbuton should be as many as 24 kg/m2 (equivalent to 5 kg of bitumen). With the combination of these conditions (no initial bounding and less asphalt), delamination will be occured on asbuton layers from aggregate layers, aggregate release of the road pavement is also easier to occur on this road. High water content (> 2%) contained in asbuton is also predicted to contribut the occurrence of delamination damage.

At EelHaji-Ereke segment conducted in 2009, the dominant damage is plastic deformation that is equal to 14.23% of the surveyed area of road surface. With the use of grained asbutons with 21.6% bitumen content of 24 kg/cm$^2$ (equivalent to 5.18 kg/m$^2$ of bitumen) plastic deformation should not happen on this road. From the test pit results shown that liquid asphalt or asphalt emulsion use for the initial bound between the surface aggregates with grianed asbuton spread on it, the asphalt infiltrated into these layers up to several cm and bound compacted grained asbuton quite well but it tend to flow. This is an indication that the quantity of liquid asphalt or asphalt emulsion is given for the initial bound is too much. The too much usage of liquid asphalt or asphalt emulsion for initial bound will cause, plastic deformation of grained asbuton layer will be potentially occured. This is confirmed by the fact that the grained asbuton grain used is penetration value of 39. With this hardness, the plastic deformation damage should be not occured. It can be concluded from this that the provision of liquid asphalt or asphalt emulsion for the initial bound is very important to produce a good butur seal performance, but the usage of it with an excessive quantity is also not good. However, lack of data collection at the time of execution lead to what quantity of liquid asphalt or asphalt emulsion that is used to provide adequate initial bound can not be determined in this study.

Meanwhile in road segment of Membuku-Ereke conducted in 2008, the dominant damage is crack by 20.68% of road surface area surveyed. The use of grained asbutons with bitumen content of 21.9% is 16 kg/m2 (equivalent to 3.5 kg/m2 bitumen) as a binder and cover layer of aggregate perceived inadequate. Moreover, the used of asbuton is quite hard (pen 21), where according to the theory of asphalt mixture, cracked will occur when asphalt penetration is less than 30 and in fact, cracks frequently occur in this roads. These factors are predicted to be the cause of cracks that occur on Membuku-Ereke roads segment.

The use of liquid asphalt or asphalt emulsion for the initial bounding on layer aggregate in the road before grained asbuton spreaded is quite adequate and shown a good performance shon by the fact that on Membuku-Ereke roads segment there no delamination between grained asbuton layer dan aggregate surface as shown in Figure 10. However, from this study, quantity of liquid asphalt or asphalt emulsion for initial bounding can not be determined because the lack of limited data.

From the types of damage are given in Table 1 and thick layers of asbuton in Table 2 can be concluded that the thickness of 1 cm of grained asbuton is susceptible to ravelling or cracking, but with a thickness of 1.5 cm, both types of damage did not occur. For this thickness, when on the layer of aggregate prior sprinkled with grained asbuton given a significant amount liquid asphalt or asphalt emulsion as the the initial bound, plastic deformation damage may be minimized.

Figure 10. The Effect of Liquid Asphalt or Asphalt Emulsion for Initial Bounding between Grained Asbuton with Aggregate Surface

As an important note from this study, the three samples grained asbuton used in the field, one of type (B50/30) did not meet the required properties of B50/30 specified by Bina Marga's Specification and the other two the types can not be determined (B5/20, 15/20, B15/25, B20/25, B30/25 or B50/30) because the the resulting characteristics are not matches any type.

## IV. CONCLUSIONS AND RECOMMENDATIONS

### 4.1. Conclusion

- For efficiency, road construction type for low-traffic in areas where the standard aggregate was hard to find, should be different which commonly widely used.
- The thickness of 17 cm butur seal is able to provide excellent performance to serve the daily traffic of about 100 vehicles per day for 3 years.
- Butur seal will provide good performance when a liquid asphalt or asphalt emulsion given on the compacted aggregate layer prior sprinkled with grained asbuton for initial bound purpose between the surface aggregates with grain asbuton.
- The quantity of liquid asphalt or asphalt emulsion used for initial bound should not too much to avoid plastic deformation of grained asbuton layer. The dosage of 0.3 kg/m2 (residue); as well as used for the LPMA-Asbuton considered adequate to generate a good initial bounding.

- In butur seal, a thick layer of grained asbuton 1.5 to 2 cm is considered adequate to serve traffic of about 100 vehicles per day.
- Grained asbutons B50/30 with a total consumption rate is equivalent to 5 kg bitumen is suitable and adequate used for butur seal.
- For low traffic, the use of butur seal has been proven provide better performance compared to the unpaved road
- Butur seal can be an alternative as a low volume paved road, especially in areas with lack of standard aggregate.

### 4.2. Recommendations

Before carrying out butur seal, type grained asbuton used must be clear and qualify as B50/30. The usage of grain asbuton is not met with grained asbuton of B50/30 properties or inconsistent properties will cause the failure of the seal butur.

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