THE LABORATORY PERFORMANCE OF COLD MIX RECYCLING FOAM BITUMEN BASE (CMRFB-BASE) USING LIME FILLER

E. Susanto Hariyadi[1], A. Atmaja[2]
[1]*Lecturer, Civil Engineering Departement, Fakultas Teknik UIKA Bogor (erisdi@yahoo.com)*
[2]*Magister Program Civil Engineering-Bandung Institute of Technology*

ABSTRACT

THE LABORATORY PERFORMANCE OF COLD MIX RECYCLING FOAM BITUMEN BASE (CMRFB-BASE) USING LIME FILLER). Due to the demand of road infrastructure increases in Indonesia, it needs an alternative technology having economically, effectively and efficiently results. Reused (recycling) the existing old pavement materials may be one solution. It's expected repairing and improving structural capacity of pavement. One of technology that can be used either for repairing or improving the quality of recycling materials is foam bitumen.

The objective of this research is to evaluate the characteristics and to know the strength value of cold mix recycling base by foam bitumen using lime filler. This research uses four types variance of foam bitumen, that is 2%, 2,5%, 3% and 3,5%, and two types of lime filler (1% and 1,5%). According laboratory result is got CMRFB-Base strength based on Indirect Tensile Strength (ITS). If the sample with filler 1%, the standard of optimum foam bitumen is 2,5% with ITS dry about 186,34 KPa, ITS soaked about 125,75 Kpa and TSR is 67,49%. Meanwhile, for the sample with the filler 1,5%, the standard of optimum foam bitumen is 2,5% with ITS dry about 207,71 KPa, ITS soaked about 168,17 Kpa and TSR is 80,96%.

For the lowest Static Modulus approximately at foam bitumen 3,5% with filler contain 1,5% = 627,54 MPa and filler contain 1% is around 633,08 Mpa. For the highest Static Modulus approximately at foam bitumen 2,5% with filler contain 1,5% is around 1.857,29 MPa and filler contain 1% is around 1.268,62 MPa.

Keywords : Recycled asphalt pavement, foamed Bitumen, hydrated lime

1. INTRODUCTION

Due to the demand of road infrastructure increases in Indonesia, it needs an alternative technology having economically, effectively and efficiently results. Reused (recycled) the existing old pavement materials may be one solution. It is expected repairing and improving structural capacity of pavement. (Yamin and Widayat, 2008)
Many reasons have been put forward for asphalt recycling. As the overall condition of road pavements continues to deteriorate, the standard of road network continues to decline. The situation is getting worse as the volume of traffic continues to grow. This requires increasing effort to maintain and rehabilitate the existing pavements. Since most of road agencies face budget constrains, the focus is on achieving more with the same expenditure. Recycling is one of the most effective methods to achieve these goals. Recycling also reduces the impact of pavement construction on environment by reusing depleting natural resources, reducing energy consumption and reducing green house emission (Uzarowski, et.al., 2008)

Since raw materials are becoming more expensive, it is becoming more important to find ways to reuse the materials already in-place in the roadway. The use of in-place materials saves energy because the materials are processed in-situ, which greatly reduces the trucking required to haul away old pavement materials as waste

Foamed Asphalt was first developed in Iowa as a method to stabilize soil (Csanyi, 1957). In the decades since the inception of foamed asphalt, pavement recycling technology advanced to the point where it could be commonly used for roadway rehabilitation. It was not long before the foamed asphalt concept was combined with recycled pavement stabilization as a common-use technique. Subsequent increases in crude prices in the 1970's caused foamed asphalt to gain popularity for use in base and reclaimed pavement stabilization as recycling and foaming technology continued to improve. Since the 1970's the use of foamed asphalt for stabilizing base and reclaimed materials has once again increased in popularity with increases in crude oil prices, and increased environmental and energy concerns. Subsequent addition of foamed asphalt to the reclaimed bituminous pavement enhances its strength and moisture resistance. (Eller and Olson, 2009)

This paper intended to evaluate the performance of reclaimed asphalt pavement stabilized by foamed bitumen. The lime material is also used as a filler to improve the performance of material mix (Ali, 2002). This kind of reclaimed of asphalt usuallly used for pavement base underlying cement treated based and surfacing by asphalt concrete. The laboratory performance is characterized by Indirect Tensile Strenght and related Static Modulus.

2. RECYCLED ASPHALT PAVEMENT

Recycled is defined as "the reuse, usually after some processing, of a material that already has served its first-intended purpose". The use of RAP allows for a lower mix material cost, elimination of the RAP disposal costs, and removal of a waste product from landfills (Putman, et.al., 2002). The Asphalt Recycling and Reclaiming Association (ARRA) recognizes five types of recycled asphalt pavement (ARRA, 2001) :

- Cold Planing — The asphalt pavement is removed to a specified depth and the surface is restored to a desired grade and cross slope and free of humps, ruts and other surface imperfecections. This pavement removal or "milling" is completed with a self-propelled rotary drum cold planing machine. The reclaimed asphaltpavement (RAP) is transferred to trucks for removal and stockpiled for hot or cold recycling.

- Hot Recycling — RAP is combined with new aggregate and asphalt cement and/or recycling agent to produce hot mix asphalt (HMA). Although batch type hot mix plants are used, drum plants typically are used to produce the recycled mix. Most of the RAP is produced by cold planing but also can be produced from pavementremoval and crushing. The mix placement and compacting equipment and procedures are those typical of HMA construction.
- Hot In-Place Recycling — The recycling is performed on-site, in-place and thepavement typically is processed to a depth of from 20 to 40 mm (3/4 to 1-1/2 in.).The asphalt pavement is heated, softened and scarified to the depth specified. Anasphalt emulsion or other recycling agent is added, and with one of the process-es, new HMA is incorporated as required. The three hot in place recycling methods are heater-scarification, repaving and remixing.
- Cold Recycling — Although cold recycling is performed using the central or sta-tionary plant process, the method most commonly used is cold in-place recycling (CIR). For CIR, the existing asphalt pavement typically is processed to a depth of from 50 - 100 mm (2 - 4 in.). RAP is combined without heat and with new emulsified or foamed asphalt and/or a recycling or rejuvenating agent, possibly also with virgin aggregate, and mixed at the pavement site, at either partial depth or full depth, spread and compacted to produce a base course. Cold recycled bases require a new asphalt surface. Lower traffic pavements may use an asphalt emulsion surface treatment. Higher traffic pavements may use a modified emulsion surface treatment or an HMA surface.
- Full-Depth Reclamation — With FDR, all of the pavement section, and in some cases a predetermined amount of underlying material, are mixed with asphalt emulsion to produce a stabilized base course. Base problems can be corrected with this construction. Full depth reclamation consists of six basic steps: pulveri-zation, additive and/or emulsion incorporation, spreading, compacting, shaping, and placement of new asphalt surface.

3. FOAMED BITUMEN

The use of foamed bitumen as a stabilizing agent is not a new idea. Csanyi (1957) investigated the possibility of using the foamed asphalt as a binder for soil stabilization. Figure 1 shows the schematic of the asphalt foaming process. Foaming of the asphalt reduces its viscosity considerably and has shown to increase adhesion properties making it well suited for mixing with cold and moist aggregates. No chemical reaction is involved, only the physical properties of the asphalt are temporarily altered. When the cold water comes into contact with the hot asphalt, it turns into steam and then gets trapped in the asphalt as thousands of tiny bubbles. After a few minutes, the asphalt will regain its original properties once the steam evaporates. (Romanoschi, et.al., 2003).

The first reported use of foamed bitumen dates back to 1957 on an Iowa county road. Several other field applications were also reported including projects in Arizona (1960) and in Nipawin, Canada (1960-1962). The original process consisted of injecting high-pressure steam, at controlled pressure and temperature, into heated penetration-grade asphalt cement. This required special equipment on the job site, such as, a boiler and was not very practical. In 1968, Mobil Oil Australia modified the original process by adding cold water rather than steam, into a stream of hot asphalt in a low-pressure system. This made the process much more practical and economical. The foam was created within an expansion chamber after which it was dispersed through a series of nozzles, onto the aggregate mass. However, the nozzles were prone to blockage, and the manufacturer could not control the foam characteristics. Recently, Wirtgen GmbH of Germany, Soter of Canada, and CMI of Oklahoma City have developed new equipment for producing foamed bitumen. (Romanoschi, et.al., 2003)

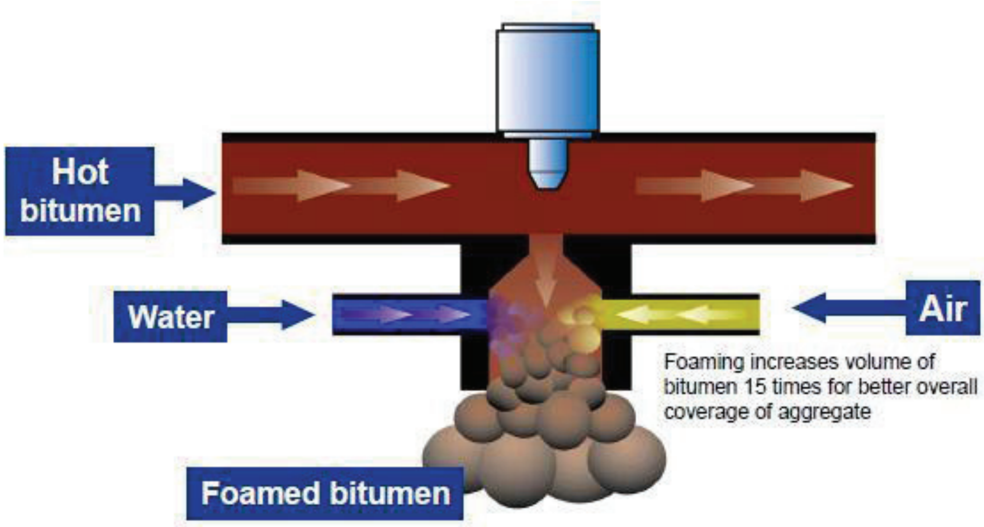


Figure 1. Schematic of Foamed Bitumen Production (Wirtgen, 2004)

In the laboratory, foamed bitumen is produced by Wirtgen WLB 10 (figure 2) and mixed by Hobart Mixer to produced bituminuous mix. This equipment resulting foamed bitumen which has the same characteristic with that equipment in site which called Wirtgen WR 2500.

Figure 2. Wirtgen WLB 10 Equipment

4. RESEARCH METHODOLOGY

The methodology of this research is described in Figure 3 below.

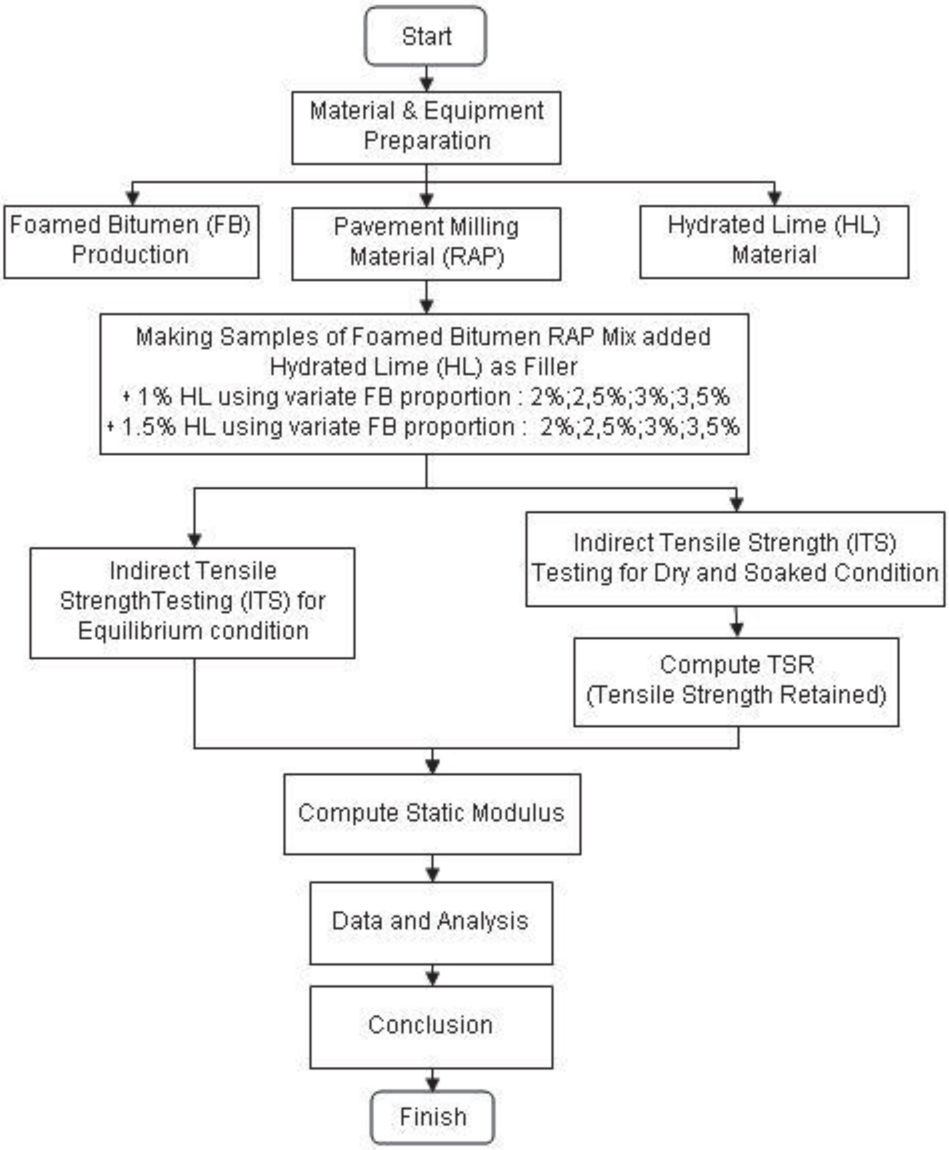


Figure 3. Research Methodology

This methodology basically comprise to material preparation, sample preparation, indirect tensile testing, analysis and conclusion. Material for this research mainly consist of foamed bitumen, recycling pavement material and hydrated lime. The foamed bitumen is produced by Wirtgen WLB 10 equipment in laboratorium. The recycled pavement material are taken from Cirebon-Losari Road preservation project and hydrated lyme material comes from Padalarang Bandung.

5. RESULTS AND DISCUSSION

5.1 Aggregate Gradation

The corresponding RAP gradation should conform with the Pusjatan Specification for CMRFB Base (Pusjatan, 2009) as shown on Table 1.

Table 1. Aggregate Gradation for CMRFB Base based on Pusjatan Specification

Ukuran Ayakan		% Berat Yang Lolos
ASTM	(mm)	
2"	50	100
1"	25	77 – 100
¾"	19	
½"	12,5	63 – 87
3/8"	9,5	
No.4	4,75	45 – 68
No.8	2,36	35 – 57
No.30	0,600	19 – 39
No. 100	0,150	8 – 25
No.200	0,075	5 – 20

The RAP material source which taken from Cirebon Losari should be tested for gradation and conform with the specification. The results for this test as shown on Figure 4.

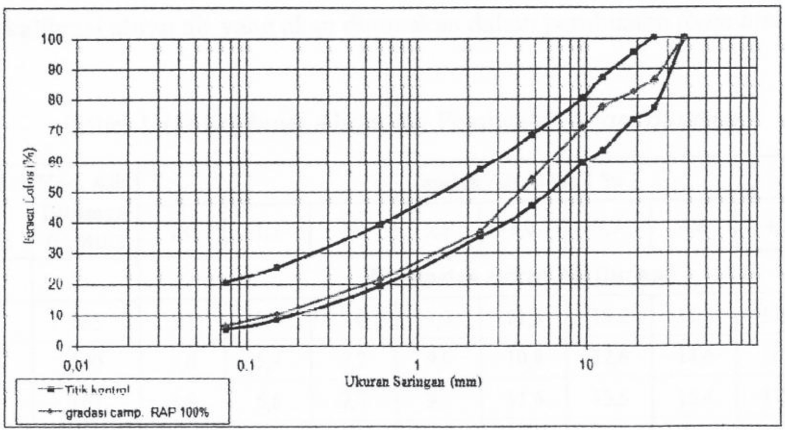


Figure 4. Aggregate Gradation for RAP Source

This graph indicate that RAP gradation is in the specification limit. This will conclude that adding virgin aggregate is not applied to improve the aggregate gradation.

5.2 Foamed Bitumen Production

The equipment to produce the foamed bitumen in laboratory was Wirtgen WLB 10. This equipment required some parameters resulting the expected foaming content. The four variations of foamed bitumen content were used in this research are 2%, 2.5%, 3%, 3.5%. Figure 5 indicate 2.437% optimum foaming water to produce 2% foamed bitumen content

.

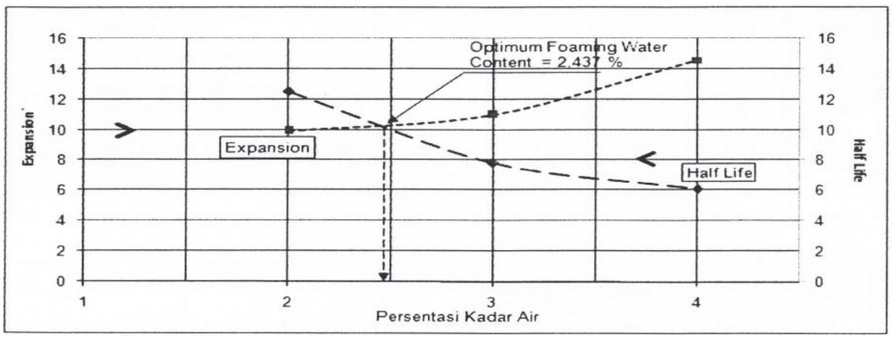


Figure 5. The Expansion and Half Life for 2% Foamed Bitumen Content

All other optimum foaming water content can be determined in the same way and described in Figure 6. This figure indicate that increasing the foamed bitumen content will lead to decreasing the required optimum foaming water

.

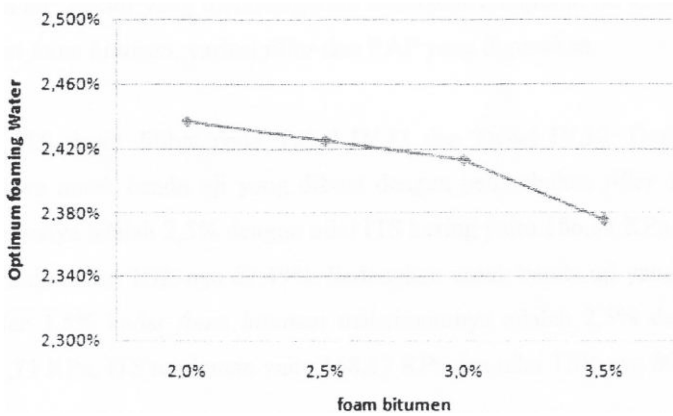


Figure 6. Optimum Foaming Water

5.3 Mix Design

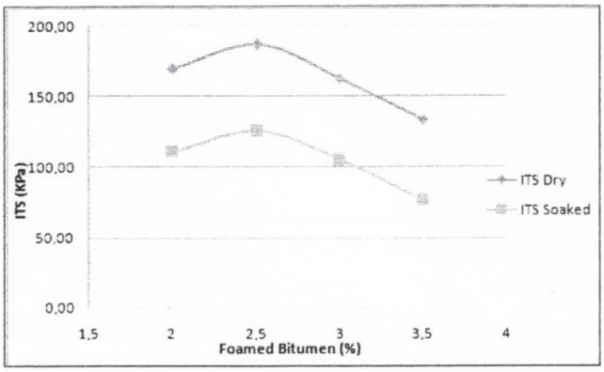
The laboratory mix design for the foamed asphalt stabilized base materials was done at the Pusjatan Laboratory in Bandung. Recycled asphalt pavement (RAP) samples to be used in this research were shipped to the laboratory to develop the mixture design. A Wirtgen Foamed Bitumen Laboratory Plant (WLB 10) was used in the mix design process.

The optimum water content for foaming was found to be at 2,437%, 2,425%, 2,413%, 2,375% water injection rate at a binder temperature of 160°C for 2%, 2.5%, 3%, 3,5% required foamed bitumen content repectively. This mix design was conducted for 1% and 1.5% hydrated lime content as a filler.

The 10 kg RAP samples was added hydrated lime and mixed with foamed bitumen in Hobart Mixer during 30 seconds. Those will be compacted with Marshall compaction 2x75 resulting 10 cm diameter of briket samples.

5.4 Indirect Tensile Strength Testing

Results of indirect tensile strength (ITS) testing for the mixtures prepared with 1% and 1.5% hydrated lime are illustrated in Figures 7. The tensile strength ratio (TSR), which is a measure of a mixture's resistance to moisture damage, is also described in the next figures.



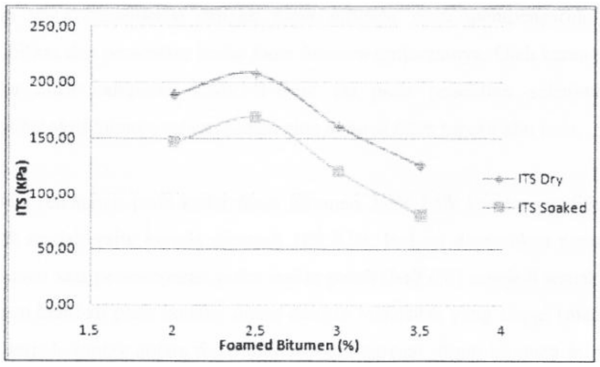


Figure 7. ITS Testing for CMFRB with 1% and 1.5% Hydrated Lime Content

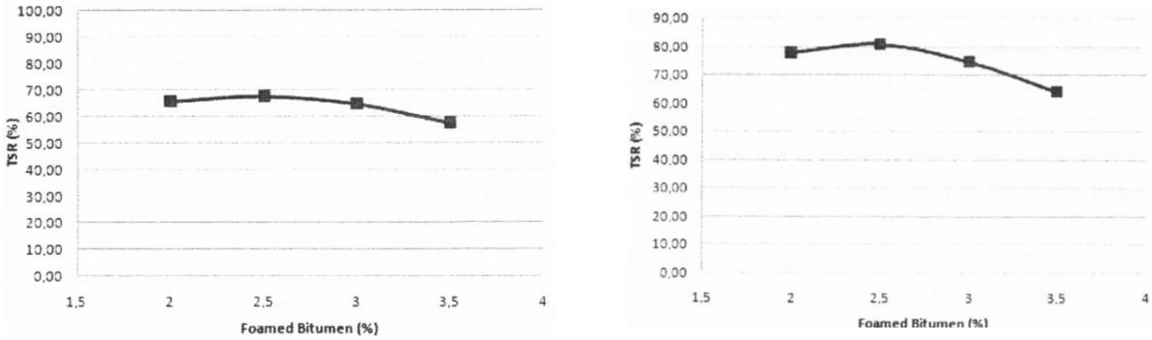


Figure 8. TSR value for CMFRB with 1% and 1.5% Hydrated Lime Content

Indirect Tensile Strength (ITS) testing at equilibrium condition was also conducted to compute Static Modulus parameter for 1% and 1.5% hydrated lime content as a filler. Equilibrium condition which represent existing moisture condition was applied to plastic wrapped samples and dried in 40°C during two days. The results of indirect tensile strength (ITS) testing at equilibrium condition with 1% and 1.5% hydrated lime are illustrated in Figures 9.

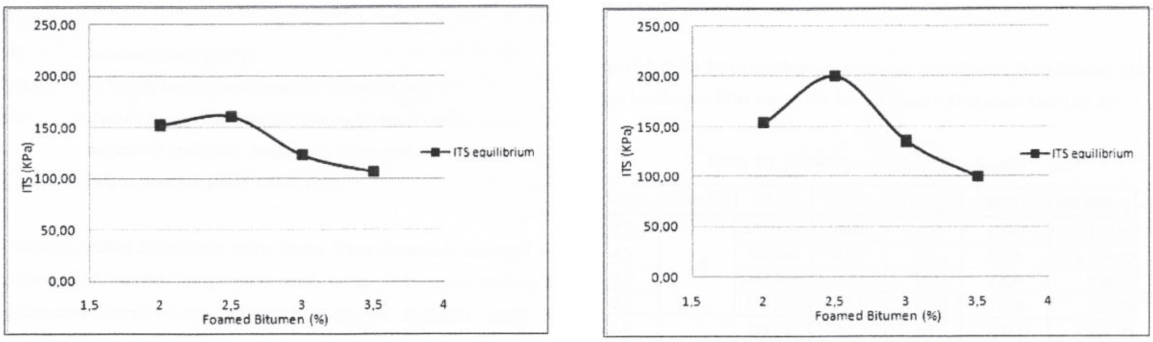


Figure 9. ITS Equilibrium Testing for CMFRB with 1% and 1.5% Hydrated Lime Content

5.5 Static Modulus

The parameter of Static Modulus was used to characterize the foamed asphalt as pavement bases. Wirtgen (2004) introduce Structural Layer coefficient for foamed asphalt in pavement analytical design using static modulus.

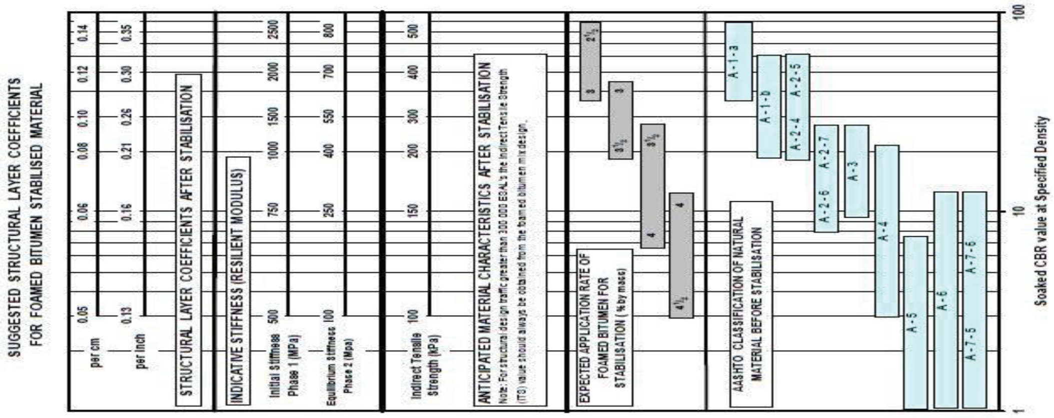


Figure 10. Structural Layer Coefficient for Stabilized Foamed Asphalt Material

In order to compute the Static Modulus parameter, the equation below was applied using ITS equilibrium and TSR from Indirect Tensile Strength testing. The related drainage factor was also applied.

$$MS = (\log (ITS_{equ}) x3950-7000) xTSRxF_{drainage} \quad \text{.....................................(1)}$$

From equation 1 the computed Static Modulus can be described in Table. 2 and Figure 11.

Tabel 2. The computed Static Modulus

FB (%)	Filler (%)	ITS equ	TSR	F drainage	Log(ITS equ)	MS (MPa)
2,0	1,0	152,141	0,65	1,1	2,182	1.166,99
2,5		160,247	0,67	1,1	2,205	1.268,62
3,0		122,753	0,65	1,1	2,089	889,98
3,5		106,081	0,57	1,1	2,026	633,08
2,0	1,5	153,818	0,78	1,1	2,187	1.401,70
2,5		199,574	0,81	1,1	2,300	1.857,29
3,0		134,900	0,75	1,1	2,130	1.161,21
3,5		99,416	0,64	1,1	1,997	627,54

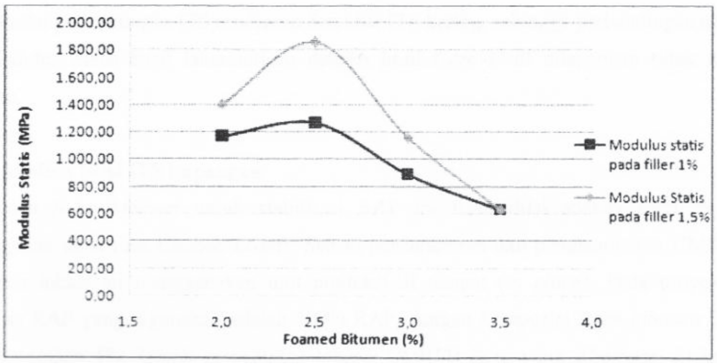


Figure 11 The Static Modulus for each Foamed Bitumen Content

6. CONCLUSION

- The maximum of ITS value for CMRFB-Base with 2.5% foamed bitumen content using 1.5% Hydrated Lime was 207,71 Kpa (dry) and 168,17 Kpa (soaked).
- The 80.96% TSR value as required on Pusjatan Specification was fulfilled by 2.5% foamed bitumen content using 1.5% Hydrated Lime.
- All the static modulus values obtained from this research were above 1000 Mpa except for 3.5% Foamed bitumen content. However the highest static modulus was reached by 2,5% foamed bitumen content with 1.5% hydrated lime (1.857,29 MPa).
- The optimum foamed bitumen content for CMRFB Base mix in this reasearch was reached by 2.5% based on maximum ITS and Static Modulus values.

REFERENCES

[1] Ali, S. 2002. Laboratory Performance of Lapis Tipis Aspal Beton (Lataston) using Lime Filler. Thesis. Magister Program of Highway Engineering and System. Bandung Institute of Technology.

[2] ARRA. 2001. Basic Asphalt Recycling Manual. US Department of Transportation FHA.

[3] Csanyi L.H. 1957. Foamed Asphalt in Bituminous Paving Mixtures. Highway Research Records No. 160, National Research Council, Washington, DC, pp. 108-122

[4] Eller, A. Olson, R. 2009. Recycled Pavement Using Foamed Asphalt in Minnesota. Research Report. Minnesota Department of Transportation.

[5] Putman, B.J. Aune, J. Amirkhanian, S.N. 2002. Recycled Ashalt Pavement (RAP) Used In Superpave Mixes Made With Rubberized Asphalt. Clemson University. South Carolina USA.

[6] Romanoschi, S.A. Hossain, M. Heitzman, M. Gisi, A.J. 2003. Foamed Asphalt Stabilized Reclaimed Asphalt Pavement : A Promising Technology for Mid-Western Roads. Proceedings of the 2003 Mid-Continent Transportation Research Symposium, Ames, Iowa. Iowa State University.

[7] Uzarowski, L. Manolis, S. Lu, P. Greco, M. 2008. Initial Evaluation of Foamed Asphalt Stabilization Using Modified Asphalt Cement. Proceeding of Soils and Material : Warm Asphalt as Sustainable Strategy for Pavement Conference. Ontario.

[8] Wirtgen GmbH. 2004. Wirtgen Cold Recycling Mnual, 2nd Edition, Germany.

[9] Yamin, A., Widayat, D. 2008. The Application of Foamed Bitumen for Recycled Asphalt Pavement. Road and Bridge Journal Volume 25 No.2. page. 130-153.