Design of the strong and durable of flexible pavement on road segment with the heavy traffic and overloads

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Abstract. The arterial road sections are generally heavy vehicles that tend to exceed the standard load so that the existing pavement surface is not able to survive according to the design life despite using modified asphalt. This has been proven by the occurrence of a heavy damage in a relatively short time on most primary arterial roads in Indonesia. In this paper, the method of implementation and criteria for the construction of pavement layers with a certain thickness has been prepared according to the planning standard for the volume of excessive vehicle loads and taking into account extreme weather conditions in Indonesia. There are three (3) main things in this paper that become an important factor in determining the structure of a solid and durable; they are the sand as layer controlling deflection (stabilizer), the weight of the Vibratory roller more than 25 tons to achieve maximum of compaction energy for base course, and a single-layer of AC-Base as a surface layer as anticipation of rutting and bleeding. Single overlays in each layer are rigidly constraining overall construction, while the sand layer can neutralize deflection due to overload and force due to the vertical force of subgrade, so that these three factors are energy deposits in the pavement construction that will work when an increase in load exceeds the standard.

1. Introduction
The primary arterial road in the north coast area of Java is a road with a super heavy load, so that the average pavement age of less than 3 years has experienced quite severe damages. The damage begins with rutting, bleeding down, and waves and grain spills occur until it becomes a fairly large hole and increases very quickly, especially in the rainy season. Damage repair only lasts a maximum of 1 year so that the surface conditions are relatively uneven because there are so many fillings of holes and waves. The average annual maintenance cost for the north coast area of Java road per kilometer is around 80 million rupiah (4 lanes), but with the allocation of these funds, the road surface conditions are still uncomfortable and tend to be damaged.

AC-WC and AC-BC are not able to serve repetition of heavy loads that especially tend to be excessive, so that the carrying capacity of the surface layer is smaller than the compression force load of the vehicle with tire pressure wheel. From lecture module book of Indrasurya, it is stated that the minimum marshal stability value (in kg) is 10 vehicle tire pressure (psi), so that if the truck tire pressure is 160 psi then the minimum stability value is 1600 kg. If the stability value of the Marshall AC-WC and AC-BC Modification is only 1000 kg, it is very reasonable that it is not able to support the vehicle load with tire pressure up to 160 psi. Therefore in this paper, we will discuss in detail about the placement
of AC-Base as a surface layer in an effort to support repetition of heavy loads that tends to be excessive to minimize the occurrence of rutting and bleeding.

In addition to AC-Base as a surface layer used as a material for discussion, the overlay method, especially in relation to a single AC-Base overlay, is also the material of analysis in this paper because there is a significant difference between a single stretch and layer by layer when viewed in terms of the robustness of the pavement layer structure. Analysis of the occurrence of failures for laying on a layer by layer mixture system is also discussed in this paper, so that the selection of a single overlay against the AC-Base layer to achieve a sturdy and durable surface layer structure can be achieved to the maximum.

The foundation layer was chosen by CTB as the right material because CTB is not affected by the presence of high ground water during the rainy season, as well as it has a relatively higher coefficient value than the grained aggregate foundation layer so as to minimize the thickness of the upper foundation layer. Another thing that is important to use CTB as the upper foundation layer is that the CTB is spread with optimum moisture content conditions, so that it is easier to achieve maximum density at all points of the base course layer. This is very beneficial because so far the optimum water content in the base course layer (aggregate A) and sub-base course (Aggregate B) has never achieved optimum water content in all parts of the thickness of the layer including the surface layer.

Condition of water content is often considered trivial, whereas the maximum density is achieved when the optimum moisture content is in the range of +1 to -3% of the value of the optimum moisture content. The grained foundation aggregate that is sent in the field is definitely not clear with what the water content is, if it has been piled in the field and left for days, sometimes it gets rained on and sometimes sunburned so that it gets farther from the optimum water content conditions. At the time of distribution and compaction, the average water content in each pile is also not tested so that an amount of water can be added based on the field density value determined in the JMF. What happens is that the field only adds water without any calculation, resulting in varying degrees of density at a number of surface locations, and eventually the surface becomes a longitudinal and transverse direction waves.

The existence of waves on the road surface cannot be considered trivial because these conditions are the triggers for more severe damages, the presence of waves can cause shock loads that are up to 2-2.5 times the weight of the existing loads. This is very dangerous especially when overloaded by heavy vehicle loads, so as if the location of the valley (concave) receives multiple overloads again. This is evident in the road section that is traversed by heavy and heavy traffic if there are symptoms of deflection and small waves, then in a relatively short time it will turn into a large puddle during the rainy season. On the basis of this compaction method, providing optimum water content is a matter that must become a separate consideration.

Compaction energy produced by the weight of the compactor is very influential on the robustness of the construction of the aggregate foundation layer, the greater the weight of the compactor the greater the effect on the thickness of the layer. This should become the main consideration when carrying out compaction, if a lightweight compactor is used then the thickness of the overlay layer is small enough, so that to achieve the thickness of the plan, several layers are required. The weakness of the structure of the foundation layer construction which is composed of several thin layers is not as solid as a single layer according to the design thickness. Analysis of weaknesses in the arrangement of layer thicknesses composed of several layers will be discussed further in the analysis chapter.

The sand layer deliberately installed in the design of flexible pavement construction structures is intended to control the existence of excessive load which is expected to cause deflection that exceeds the permit deflection of the rigidity (modulus) of the existing design construction structures. Besides, sand is also needed as a stabilizer when the subgrade which has a very low CBR is submerged in water during the rainy season, where conditions are very weak, then some of the sand thickness will function as a form of subgrade repair, so that the structural conditions remain stable. Similarly happens during the compaction of the foundation layer with a compactor that is heavy enough, so that the sand can be used as a supporting layer so that the subgrade layer is not completely disturbed by the compaction energy that occurs.
2. Intent and purpose
This paper aims to solve the problem of flexural road damage due to overload and tropical climate that can soften hot asphalt mixes during the day, as well as subgrade conditions that are disturbed by the level of rigidity of the pavement construction layers which are designed according to the technical requirements and technical planning criteria for road pavement thickness.

The main goal of this paper is to create a design system that is sturdy and durable on flexible pavement based on the characteristics of the material, the stabilizer layer, the method of implementation and weight of the compactor for the foundation layer, and the selection of the most appropriate type of surface layer.

3. Literature study
A sturdy and durable road in serving traffic volume during the life of the plan is highly desirable, moreover it can serve up to more than 40 years of age (perpetual pavement) where during the service period only minor routine maintenance is carried out, but the value of surface conditions is quite good, a maximum IRI value of 6. In Indonesia, it seems that this is impossible because many factors can cause damage in a relatively short time, including road users not obeying regulations (overloading), tropical climate so that the heat on the road surface is more than 60 °C, construction material, construction method, capacity and condition of compactor, and relatively high rainfall. These things should become the variables taken into account in the comprehensive flexible pavement construction arrangement. Meanwhile, standard design only considers 3 main variables, namely subgrade (CBR), traffic data (ESAL accumulation) according to design life of pavement and drainage system.

Calculation of traffic data must be examined carefully, especially the problem of excess vehicle planning as a result of incorrect volume prediction during the service period (planning year), incorrect setting growth factors, not paying attention to land use (spatial mapping), and transportation industry changing configuration axis so that the amount of load increases, but the number of wheels remains, or modifies the type of tire so that it is able to accept greater pressure and lift capacity. This must be understood by planners so that in calculating the volume of heavy traffic, they must take into account these things and convert them into ESAL values. The accumulation of ESAL values resulting from the conversion is expected to approach the actual conditions in the field during the service life according to the planning results.

The occurrence of rutting is caused by 2 important things, namely the characteristics of asphalt as a binding material and the aggregate quality as the results of the aggregate characteristics test. The characteristics of asphalt include softening point and viscosity, where asphalt is expected to have high elasticity at low temperatures so it is not easy to break / crack, and high viscosity so that when the temperature in the field is high and the mixture is not easily softened / weakened. In other words, the asphalt softening point is high, but the penetration is also still high so that the mixture is neither brittle nor softened. Meanwhile, the quality of the aggregate is mainly related to the coarse cubical shape of the coarse grains and has a maximum abrasion value of 30% for each grain. To get the maximum mechanical bonding, it takes more than 50% of the coarse aggregate fraction in the mixture. Mechanical ties are bonds that lock together/ bind (interlock) so that they are eternal. Therefore, if the conditions in the field obtained asphalt mixture with a more dominant type of mechanical bonding, it is certain to be very resistant to repetition of heavy vehicle loads with excessive loads so that rutting and bleeding do not occur.

To obtain the characteristics of asphalt that is able to provide high elasticity and high viscosity values, it must be modified with synthetic elastomeric material and rubber (natural and in the form of crum rubber). If the mixture uses the modified asphalt, then there is an appropriate temperature calibration for the implementation of mixing, spreading and compaction. The composition of the modified modification asphalt must be known in advance to meet all the characteristics, especially the portion of added ingredients (additives and rubber / latex). After obtaining the correct modification of asphalt, a mixture of aggregate and asphalt was tested with proportions that meet the characteristics of the mixture in the laboratory. Modification of asphalt viscosity testing is needed to find the right temperature at the time of mixing, spreading and compaction. Meanwhile, elastic recovery test is needed to get the modified asphalt elasticity value so that it can be used to control the occurrence of cracks.
The SHRP researchers determined that rutting is a controlled tensile stress to the phenomenon of repetitive traffic loads, commonly referred to as workloads. Some of the workloads are accommodated by the strength of the pavement surface elasticity, while others are stored in the pavement in the form of permanent deformation and heat. To minimize the occurrence of permanent deformation, it must minimize the stored work energy when there is a repetitive traffic load. The mathematical formula for stored energy due to repetitive traffic loads is as follows:

\[ W_c = \pi \times (\sigma^\circ)^2 \times \frac{1}{G^* / \sin\delta} \]  

(1)

Where:
\( W_c \) = stored workload every repetition of traffic loads 
\( \sigma^\circ \) = tensile stress during traffic load repetition 
\( G^* \) = complex modulus 
\( \delta \) = space angle

From the formula above, it appears that the rutting value can be reduced or asphalt material can be made more resistant to rutting by increasing the modulus of the complex, \( G^* \) or making asphalt more rigid and reducing the value of \( \delta \), or making asphalt more elastic. This concept has been developed by the Superpave method.

Modified asphalt used as a binder in the mixture in the 2018 Bina Marga technical specifications must meet the technical requirements as Type 2 asphalt namely PG-70 and PG-76 asphalt. However, implementation control in the field is not fully able to meet these requirements because not all laboratories have testing equipment for the modified asphalt modification criteria, specifically the complex shear modulus (\( G^* \)) and the space angle (\( \delta \)) on dynamic shear strength testing (Dynamic Shear Rheometer, DSR).

![Figure 1. DSR testing to determine the values of G * and δ](image-url)
The formula for calculating variables in the DSR measurement is as follows:

$$G^* = \frac{\tau_{\text{max}}}{\gamma_{\text{max}}}$$  \hspace{1cm} (2)

$$\tau_{\text{max}} = \frac{2T}{\pi r^2}$$  \hspace{1cm} (3)

$$\gamma_{\text{max}} = \frac{\Theta r}{h}$$  \hspace{1cm} (4)

Where:

- $G^*$: complex modulus
- $\delta$: space angle (time difference)
- $\tau_{\text{max}}$: maximum shear stress
- $\gamma_{\text{max}}$: maximum shear strain
- $Q$: maximum rotating voltage
- $r$: the radius of the test specimen 4 mm or 12.5 mm
- $\Theta$: deflection (rotation angle)
- $h$: height of test specimens is 1 mm or 2 mm

Material is called viscoelastic when the value is: $0 < \delta < 90 \degree$ C

Meanwhile, if the proportion of mixed grading has been obtained where the coarse grain fraction is more than 50% and cubical, then the type of asphalt modification is no longer needed because the interlock ability between coarse grains is much greater than the strength of the modified asphalt bond, meaning that the asphalt function as material binders can be minimized, and mechanical ties of this kind if they occur evenly in asphalt mixtures will become very strong and durable mixes due to the effects of weather and water cannot work, so they can be said to be an eternal mixture or referred to as perpetual pavements that can last up to more than 40 years.

What is meant by the coarse aggregate fraction in this paper is not merely retained in sieve no.4 (4.75 mm), but the coarse fraction which is the body of the mixture (interlock dominant fraction), where the AC-WC mixture is 5 - 10 crush-stone (medium), and AC-BC is 10 - 15 crush-stone (medium tends to be rough). In accordance with the grading requirements in the specification that combined grading for each type of surface layer, the maximum grain size is set only in the range of 0-10%. In AC-Base mixture, the aggregate, which is a mixed body, is 10-20 grain size around 38-48 %, so that the aggregate fraction as the main support of mechanical bonding is able to increase the Marshall Stability value of AC-Base of more than 2250 kg when using modification asphalt, whereas if using non modification asphalt, Marshall values can be more than 1800 kg, with this value alone is sufficient to support heavy traffic and overloads.

4. Problems and alternative solutions

As discussed earlier, the problem of damage includes several causes, ranging from the supporting layers (if any), the grained aggregate foundation layers, the CTB, and the surface layers, all of which are mutually supportive and integrated as a whole. For example, if the strength of the support layer is not uniform because there are large grains (of more than 10 cm) which are spread out and compacted, then in less than 2 years the surface conditions must have waves with a peak point at the location where the large rock is located. Waves on the surface of the asphalt mixture will cause a shock load, so that the location of the break (concave) will receive an additional force of 2-2.5 times the weight of the load carried when heavy vehicles pass. Then within that relatively short time, it will become an increasingly severe damage if not promptly given a leveling layer at the location of the sinkhole or the trough (concave section).

In general, activities in the field do not use compactors in accordance with the weight requested in the requirements, although existing compactors can be converted with thinner layer thickness and number of passes. Compaction of aggregate foundation layers made with a small compactor (small energy) will be very vulnerable to damage because it must be done layer by layer, which often occurs in the field not done with a thickness that is appropriate to the weight of the compactor. For example, a
30 cm thick bed uses only a 10 ton vibro roller weight, so that the bottom of the bed does not get enough energy, so parts that do not get enough compaction energy will be a source of weakening. Weakening in question is the occurrence of deflection and sink in when heavy vehicles pass, if the deflection that occurs has exceeded the permit limit, cracks will occur and if filled with rain water, the damage will be more severe quickly.

If the thickness of the aggregate foundation is compacted layer by layer in accordance with the weight of the compactor, and there is a load that exceeds the compaction energy (heavy load exceeds the weight capacity of the compactor) there will be a deflection between layers so that each layer will work independently, and this is a weak form. Thick overlays composed of several layers will remain sturdy if the load that passes does not exceed the permit capacity of each layer. If there is one layer that collapses as a result of overload, then the collapsed part becomes weak and will trigger the collapse of the other layers, so that it will collapse completely (total layers). Meanwhile, almost 50% of heavy vehicles in Indonesia tends to carry loads with heavy loads exceeding heavy load capacities.

In general, the condition of subgrade CBR values along the road segment is uneven, and this condition will provide different support for the flexible pavement construction layers. Differences in carrying capacity of the subgrade layer along the road can cause longitudinal and transverse direction waves if the total stiffness of the entire layer is unable to support the repetition of heavy loads that passes, therefore a stabilizer layer is needed that is able to control the forms of subgrade movement / pressure when experiencing volume changes due to the presence of ground water levels during the rainy season. This paper chooses a layer of 20 cm thick sand as a subgrade pressure stabilizer layer and as an overload controller when the rigidity of the flexible pavement layer construction is exceeded by the overload path. Sand is a single gradation that can function very effectively to divide or distribute the load acting on the layer evenly, so that the subgrade layer is not disturbed. Besides, conversely, the subgrade pressure at some locations will be neutralized by the sand layer so that it is not reflected to the surface layer.

5. Implementation of experimental activities in the field
The activity is carried out on roads that have the criteria of soft land and land that tends to be prone to high shrinkage, with heavy vehicle reps that are quite dense and tend to be overloaded, so the implementation steps are as follows:
1. Excavating the existing as deep as 95 cm to dispose of existing material because it is assumed the foundation layer has experienced mixing with clay pumped up to the surface layer, so that all excavated material will be used as the fill around outside the road shoulder.
2. The width of the excavation for half the body of the road is 4.50 meters (1 line + 1 meter shoulder), with the aim that the structure of the shoulder is the same as the pavement structure, the location of the road should be bordered by markers.
3. Spread a layer of sand zone 2 or 3 criteria as thick as 20 cm above the surface of the subgrade that has been dug and flattened, doused with water until saturated, allowed to stand for at least 4 hours so that the water seeps into the subgrade layer.
4. In addition to compacting sand, water that seeps into the subgrade layer will make the subgrade the weakest condition and represent the real conditions in the field.
5. Non-woven geotextile extend just above the surface of the sand layer that serves as an interface layer (separator), in case the pumping does not mix with layers of foundation.
6. Carry out a single layered underlay foundation (class B aggregate) with optimum moisture content as thick as 30 cm and compacted with vibro roller liner with a minimum static weight of 25 tons, with the number of compaction equipment trajectories according to field trials (JMF).
7. Carry out a single 30 cm CTB overlay, which is compacted with a vibro roller with a static weight of at least 25 tons, with the number of trajectories in accordance with the trial (JMF).
8. For curing purposes of the CTB layer which has fulfilled the technical requirements, namely flatness, density and slope of the surface according to the technical plan drawings are carried out overlaying the prime coat.
9. Particularly on heavy traffic roads, at minimum of 4 hours after the overlay of the prime coat can be sprinkled with sand or rock ash so that traffic can be opened, as well as functioning as proof-rolling to determine the degree of density visually.

10. Carry out tack coat as much as 0.2-0.5 liters / m² before exposure to the surface layer.

11. Carry out a single AC-Base overlay 12-15 cm thick with a tool that is capable of the thickness with the results according to the plan.

12. In an effort to monitor surface subsidence, initial elevation measurements are made at several locations tied to the BM that has been provided previously, so that monitoring of the decline in whole or in part can be monitored with details and can be known periodically (every year).

13. The trial location was conducted on the primary collector road of the Bojonegoro-Nganjuk section Km 58 + 450 to 58 + 675 with the road conditions as attached.

6. Analysis of determination of research layer arrangement thickness

The composition of the pavement construction layers that are the object of research is as shown in figure 2 below. With a total thickness of 95 cm, consisting of 20 cm tidal sand layer, bottom foundation layer (class B aggregate) 30 cm, upper foundation layer, CTB as thick as 30 cm and surface layer with a single AC-Base single layer 15 cm thick.

1. A 20 cm thick sand layer is used as a stabilizer layer, which is to anticipate the vertical movement of the subgrade force due to its development. The sand layer also functions as a layer of controlling heavy traffic loads that tend to be excessive because sand is a material that is easy to adjust the shape of the surface direction of the load acting on it and spread it out to all the interacting grains, so that the load pressure becomes very small along with the thick layers, in other words, sand is able to neutralize several types of work load.

2. The foundation layer that is spread with a single layer using a heavy compaction tool will produce a high degree of density and save excess compaction energy in the form of rigidity of the pavement layer structure which is very high, so that it will be able to support the overloads without exceeding the permit deflection of the existing pavement structure.

3. Surface structure designed with interlock-based bonding mechanism between cubical coarse grains will be able to survive indefinitely as long as coarse aggregate grains do not weather. Therefore, the mechanical granular bonding system based on the mechanical (interlocking) can minimize the function of asphalt as a binder, so that the surface layer is not affected by aging factors of the binder, including modified asphalt material which is not needed to create flexible pavement structures that are resistant to rutting and bleeding.

4. The accumulation of the three strengths of the pavement structure as analyzed above can be referred to as the excessive energy stored in a flexible pavement system in the form of stiffness, and will work when the load exceeds the plan so as to be able to provide services according to the age of the plan with small maintenance costs.

5. The composition of the layers referred to above is shown in figure 2.

7. Resume specification for each materials

7.1. Sand material specifications

1. Weight of loose contents of at least 1.2 tons / m³
2. Sand equivalent value of at least 50%
3. Pass the sieve No. 200 of maximum 10%

| Table 1. Gradation of sand type |
|--------------------------------|
| Filter Size | Zone I (Coarse) Gradation | Zone II (rather Rough) Gradation | Zone III (Fine) Gradation | Zone IV (Fine) Gradation |
|------------|----------------------------|-------------------------------|--------------------------|-------------------------|
| 9.60 mm    | 100                        | 100                           | 100                      | 100                     |
| 4.80 mm    | 90-100                     | 90-100                        | 90-100                   | 95-100                  |
7.2. Geotextile material specification

Table 2. Geotextile requirement

| Performance | Test Method | Unit | Requirement |
|-------------|-------------|------|--------------|
| Permittivity | SNI 08-6511-2001 (ASTM D4491/D4491M-17) | second $^{-1}$ | 0.02 |
| Apparent Opening Size (AOS) | SNI 08-4418-1997 (ASTM D4751-16) | mm | 0.60 (maximum average of roll value) |
| Ultraviolet Stability (residual strength) | ASTM D4355/D4355M-14(2018) | % | 50% after being exposed for 500 hours |

7.3. Specification of lower base layer and CTB material

1. Bottom foundation material is Class B Aggregate
2. CTB material is Class A and Cement Aggregate (3-5) %

Table 3. Technical requirements of layered foundation

| Properties | Aggregate Foundation Layer | Drainage Layer |
|------------|---------------------------|----------------|
|            | Class A | Class B | Class S |                  |
| Course Aggregate Abrasion (SNI 2417 2008) | 0 - 40% | 0 - 40% | 0 - 40% | 0 - 40% |
| Angularity, retained No.4 sieve size (SNI 7619, 2012) | 95/90 1) | 55/50 2) | 55/50 2) | 80/75 3) |
| Liquid limit, (SNI 1967, 2008) | 0 - 25 | 0 - 35 | 0 - 35 | - |
| Plasticity Index (SNI 1966, 2008) | 0 - 6 | 4 - 10 | 4 - 15 | - |
| The result of the multiplication between the plasticity index and % of material passing the sieve size no. 200 | Max. 25% | - | - | - |
| Clay lumps and friable materials (SNI 414, 2015) | 0 - 5% | 0 - 5% | 0 - 5% | 0 - 5% |
| Soaked CBR (SNI 1744,2012) | Min. 90% | 60% | 50% | - |
| The comparison of % sieve passing no. 200 and no. 40 | Max 2/3 | Max 2/3 | - | - |
| Coefficient of uniformity $C_v = D_{60}/D_{10}$ | - | - | - | > 3.5 |

Note:
1) coarse aggregate which has 95% 1 or more divisions and 90% 2 or more divisions
2) coarse aggregate which has 55% 1 or more divisions and 50% 2 or more divisions
3) coarse aggregate which has 80% 1 or more divisions and 75% 2 or more divisions

7.4. Cement requirement

1. On the market in zaq (40/50) kg.
2. OPC / PPC / PCC type
7.5. Asphalt mixture
1. AC-Base Gradation as shown in table 4
2. Thickness of asphalt covering 10 -12 microns
3. Has a mixed performance like table 5

Table 4. Arrangement gradation of asphalt surface layer mixture

| ASTM size (mm) | Thin | Fine | Coarse | Wearing | Base | Wearing | Binder | Base |
|---------------|------|------|--------|---------|------|---------|--------|------|
| 1 1/2"       | 37,5 |      |        |         |      |         |        |      |
| 1"           | 25   |      | 100    |         |      |         |        |      |
| 3/4"         | 19   | 100  | 90-100 | 90-100  | 100  | 90-100  | 76-90  |      |
| 1/2"         | 12,5 | 100  | 90-100 | 50-88   | 90-100| 90-100  | 75-90  | 60-78|
| 3/8"         | 9,5  | 70-95| 50-80  | 25-60   | 75-85 | 65-90   | 77-90  | 66-82|
| No.4         | 4,75 | 30-50| 20-35  | 20-28   | 53-69 | 46-64   | 35-54  |      |
| No.8         | 2,36 | 20-30| 16-24  | 16-24   | 50-72 | 35-55   | 33-53  | 23-41|
| No.16        | 1,18 | 14-21|       |         | 21-40 | 18-38   | 13-30  |      |
| No.30        | 0,60 | 12-18|       |         | 25-60 | 15-35   | 14-30  | 12-28|
| No.50        | 0,30 | 10-15|       |         | 9-22  | 7-20    | 6-15   |      |
| No.100       | 0,15 |       | 5-13   | 5-13    | 10-12 | 8-11    | 6-10   | 2-9  |
| No.200       | 0,075| 8-12 | 8-11   | 8-11    | 6-10  | 2-9     | 4-9    | 4-8  |

Table 5. Properties of hot asphalt mixtures

| Mixture Properties                                      | Asphalt Concrete Layer |            |            |
|--------------------------------------------------------|------------------------|------------|------------|
|                                                        | Wearing                | Binder     | Base       |
| Number of blows                                        | 75                     | 112        |            |
| The ratio of particles passing through sieve no. 200    | 0,6                    | 1,2        |            |
| with effective asphalt content                         |                         |            |            |
| Volume of Void in mixture (%)                          | Min 3,0                | Max 5,0    |            |
| Volume of Void in Mineral Aggregate (VMA) (%)           | Min 15                 | 14 13      |            |
| Volume of Void Filled with Asphalt (VFA) (%)            | Min 65                 | 65 65      |            |
| Marshall Stability, ( kg )                              | Min 800                | 1800       |            |
| Flow, (mm)                                             | Min 2                  | 3          |            |
| Marshall stability remaining after soaking for 24 hours at 60 °C (%) | Min 90                |            |            |
| Volume of Void in in mixture in refusal density condition, (%) | Min 2                 |            |            |

8. Conclusion
1. The use of sand layers (Zones 2 & 3) as stabilizer layers to control the pressure of subgrade development and the influence of forces from overload repetition.
2. The use of vibratory roller with a static weight of at least 25 tons to support the implementation of single layer foundation exposure with the effect of maximum compaction energy, so that compaction energy stored in the foundation layer is not exceeded by compaction energy from overload repetition.
3. Placement of 15 cm thick AC-Base in a single layer as a surface layer to anticipate rutting and bleeding due to repetition of heavy loads that tend to be excessive.
4. The accumulation of the three strengths of the pavement structure can be referred to as the excess energy stored in a flexible pavement system in the form of stiffness, and will work when the load exceeds the plan so as to be able to provide services according to the design life with small maintenance costs.

Acknowledgements
I would like to express my gratitude to the Head of the Public Works Department of Bina Marga in East Java Province for facilitating this research in the form of costs and facilities for material testing laboratories in supporting the implementation of this research.

To all laboratory staff which I cannot mention one by one who were very enthusiastic in carrying out this research.

Special thanks for Prof. Indrasurya, and also my group discussion partner who have helped in the completion of this paper. Thank you so much for everything.

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