The Limestone as a Materials Combination of Base Course on the Road Pavement

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Abstract. Road base coarse construction requires a foundation that must be sufficient to carry the vehicle load on the subgrade. Therefore the upper foundation layer is very directly influential on the burden received by the pavement layer. Limestone is an alternative innovation for the aggregate base coarse foundation. Based on the method of this research, an experiment was carried out to determine the aggregate test and the strength value of Limestone as a mixture of the upper foundation layers on the pavement. The cornerstone of the testing theory uses the 2010 Bina Marga General Specifications method, with the percentage of Limestone as a gross aggregate of 5%, 10%, 15%, and 20%. The number of samples used for each variation is five pieces. The test results show that a mixture of 10% limestone is the optimum result. The abrasion test showed a resistance of 25.63% and an area of 81.53% rupture. In the LL test results showed a value of 12%, IP 6.1%, CBR Soaked 94%, ɣd 2.43 gr/cm³, and W valued at 5.69 gr. Thus Limestone can be used as a combination of upper foundation layer material on road pavement.

Keywords: Base Course, Limestone, Road Pavement, Upper Foundation Layer.

1. Introduction
Indonesia is an agrarian country which at present, the majority of its population is intensively conducting mobile activities in a sustainable manner in economic development. On the basis of previous research, it was pointed out that transportation cannot be underestimated because it is closely related to the economy. Road infrastructure is a medium of transportation to play the role of the transportation sector, especially to complement the distribution of market goods and services. The availability of roads is very useful for the community to do all activities or movements such as the economy and other needs, so the volume of traffic will be more dense without the widening initiative roads are proportional to the volume of traffic, so the amount excess vehicle volume crossing a road can affect the capacity and cause an increase in the burden must be accepted by the road structure that will cause damage to road pavement structure. Planning and implementing a hard layer is very important done to be able to withstand the burden received. Hard layer planning determined by how strong the asphalt mixture, especially in the aggregate roughly, so we need an aggregate that has good violence in order to get a good pavement value or stability value. The action step in increasing the level of economic strata is, by making efforts to build a facility and infrastructure in all fields, [1], one of them is by building roads that are useful as access to mass transit transportation that results from the economic community. In connection with the increase in economic output precisely in agriculture and
plantations in Indonesia, Lumajang Regency has a significant role in this regard. The location is a supply point for large crops to increase the country’s economic strata. The highway is one of the vital transportation infrastructure for all levels of society. For this reason, the quality of the road must be ensured to serve the community well. Facts on the ground show that highways in Indonesia often suffer damage due to the poor surface of the flexible pavement surface. Another factor causing road damage is the quality of the structure of the road foundation and subgrade. There is still little research on the performance of road pavement structures on granular subgrade,[2]. This study will discuss the effect of subbase course layer thickness on granular subgrade on California Bearing Ratio (CBR) parameters and vertical direction subgrade reaction modulus (kv).

2. Literature Review

2.1 Concrete Asphalt

Asphalt Concrete (Hotmix) is a mixture of coarse aggregate, fine aggregate, and filler (filler) with asphalt binder in high temperature conditions (heat) with a composition that is examined and regulated by technical specifications,[1][2]. Hot asphalt mixture is a flexible pavement mixture consisting of coarse aggregates, fine aggregates, fillers, and asphalt binding agents with certain ratios and mixed under hot conditions,[3]. In Indonesia the types of hot asphalt mixtures that are commonly used include: Asphalt Concrete, Hot Rolled Sheet (HRS), and Split Mastic Asphalt (SMA),[4][5]. Many experiments are carried out by adding additional material to improve the quality of pavement. The literature study on the addition of additives has an influence on the characteristics of each type of hot asphalt mixture. The results of this study indicate that each additional material gives different results to the Marshall Stability, Flow, Void In Mix, Void Filled Bitumen and Marshall Quotient values,[6]. For concrete asphalt mixtures, polyethylene and latex 8 KKK additives content of 2% gives results that meet concrete asphalt specifications (except Marshall Quotient parameters), in Hot Rolled Sheet, KKK 20 latex additives, Gilsonite and materials containing cement base material give results meet all HRS B specification requirements, and the Viatop and Vestoplast additive Split Mastic Asphalt mixture provides results that meet the Split Mastic Asphalt specifications,[7]. The parameters of the vertical direction subgrade reaction modulus (kv) are defined as the ratio between the soil pressure and the decrease that occurs, which is determined from the plate load test. According to Hardiyatmo, et al. basic formula for calculating kv values for rigid plates is presented in Eq. [8][9].

2.2 Asphalt

Asphalt is a thermoplastic material that will become hard or thicker if the temperature decreases and will be soft or more liquid if the temperature increases [10][11]. Asphalt will harden and bind the aggregate in its place (Thermoplastic properties). The function for hardening is as a binder and filler,[12].

2.3 limestone

Limestone is sedimentary rock which is mainly composed by calcium carbonate (CaCO3) in the form of calcite minerals and is one 10 material for development that has been widely used by humans and used as a stabilizing agent on soils that have good performance bad and is also used on soft soil. Since a long time a mixture of clay has been widely used as building material,[13][14]. Limestone contains 98.9% calcium carbonate (CaCO3) and 0.95% magnesium carbonate (MgCO3) [15]. Lime is one of the many industrial minerals used by the industrial and construction sectors. In general, chalk is hydraulic, does not show weathering and can be carried away. Physically chalk is a white and smooth object, [16]. The basic ingredient of Limestone is Limestone.
Limestone contains calcium carbonate \( \text{CaCO}_3 \), with heating (± 980˚C) the carbon dioxide comes out and only the lime (CaO) is left. Chalk from the results this combustion when added to the water will float and crack, [17]. Lots of heat issued (like boiling) during this process, and the result is “Calcium Hydroxide (\( \text{Ca (OH)}_2 \)). Water is used for this process in a manner theoretically only 32% by weight of lime is needed, but due to intermediate factors other combustion, type of lime and so on sometimes water is needed 11 up to 2 or 3 times the volume of lime. This process is called slaking as for some the result is calcium hydroxide called slaked lime or hydrated lime, [18]. From calcium hydrate will be obtained by limestone mortel. This mortel is in the open air absorb carbon dioxide (CO2) and by chemical processes produce CaCO3

### 2.4 AC – BC mixture

This layer is a layer of pavement that is located below the layer wear (Wearing Course) and above the foundation layer (Base Course). This layer not directly related to the weather, but must have thickness and sufficient strength to reduce stress / strain due to past loads cross will be forwarded to the layer below it, namely Base and Sub Grade (Subgrade). The most important characteristic of this mixture is stability,[19]. In the application of the use of a mixture of AC-BC in the pavement structure arrangement the road can be seen in Figure

![Figure 2. Structure of road pavement structure](image)

The function of the AC-BC layer according to the Center for Transportation Infrastructure (2004) is to reduce stress and withstand the maximum load due to the load traffic, so it must have enough strength.

### 2.5 Aggregate

Aggregate / rock is hard material which when compacted, so united strongly will form the main structure of the jalantanpa or with addition of adhesive. Aggregates in quality and good qualities are needed for surface layers which directly bear the burden of traffic and spread it to the lower layer. Based on large aggregate particles, [20]. aggregates can be distinguished by:

1. Coarse aggregate, ie rocks held by sieve No. 8 (2.36mm) consisting of broken stone or broken gravel.

2. Fine aggregate, that is rocks that pass through sieve No. 8 (2.36mm) and restrained sieve No. 200 (0.075 mm) consists of the results of breaking stones or natural sand.
3. Filler aggregate, consisting of materials that pass filter No. 200 (0.075mm) not less than 75% by weight (SK. SNI M-02-1994 03).

4. Combined aggregate gradation is the aggregate aggregation gradation for the mixture paved, indicated in percent against aggregate weight, must meet boundaries and must exist outside the restriction zone (Restriction Zone).

The nature and quality of the aggregate determine the ability to bear the burden traffic. Aggregates with good quality and properties are needed for the coating the surface directly, bearing the burden of traffic and spreading coating underneath.

3. Research Method

3.1 Asphalt testing using Marshall method

Mixed designs based on the Marshall method were discovered by Bruce Marshall, and has been standardized by ASTM or AASHTO through some modifications, namely ASTM D 1559-76, or AASHTO T-245-90. On preparation test objects, there are several things that need to be considered include Number of test specimens prepared; Aggregate preparation to be used; Determination of mixing and compaction temperature; Preparation of asphalt concrete mix; Compaction of test specimens; Preparation for Marshall testing. From the results of testing with Marshall equipment obtained data as following: values of stability, volume weight, plastic fatigue (flow), VIM, VMA, asphalt absorption, thick asphalt layer (asphalt film), effective asphalt content, quotient marshall (marshall coefficient).

4. Result and Discussion

4.1 CBR subgrade layer test results

CBR testing is performed on the subgrade layer after compaction every 5 cm. This gradual compaction is intended to reach densities that are close to the density of granular soils that have been tested in the laboratory. CBR value 0.1 "obtained after calculation will be converted to kv value using the Oglesby and Hicks (1982) nomogram. Based on this conversion, the kgrade subgrade layer value of 69,796,255 kN / m³ is obtained.

| Sample Combinations         | Kr kN/m³ | Subgrade Difference (%) |
|-----------------------------|---------|-------------------------|
| Subgrade                    | 53,656,483 | -                       |
| Subgrade + Base Course      | 86,458,598 | 36,85                   |
| Subgrade + Base Course 15 cm| 110,984,23 | 63,15                   |

Table 1 shows that the addition of a 15 cm thick base course and 15 cm thick subbase can increase the kv values respectively 36,85% and 63,15% to the kv value of the subgrade layer.

Table 2 Recapitulation of CBR and kv values for all layer combinations

| No  | Sub Combination                   | Thickness (Cm) | CBR (%) | Kv (kN/m³) |
|-----|-----------------------------------|----------------|---------|------------|
| 1   | Subgrade                          | 25             | 20,97   | 69,796,26  |
| 2   | Subgrade + Subbase course 5 cm    | 30             | 25,99   | 80,645,16  |
| 3   | Subgrade + Subbase course 10 cm   | 35             | 30,13   | 87,719,30  |
| 4   | Subgrade + Base course            | 40             | 31,35   | 96,153,85  |
| 5   | Subgrade + Subbase course 5 cm + Base course | 45            | 32,8    | 106,382,98 |
| No | Sub Combination                                           | Thickness (Cm) | CBR (%) | Kv (kN/m³) |
|----|----------------------------------------------------------|----------------|---------|------------|
| 6  | Subgrade + Subbase course 15 cm                          | 40             | 41.8    | 121.951,22 |
| 7  | Subgrade + Subbase course 20 cm                          | 45             | 43.2    | 128.205,13 |
| 8  | Subgrade + Subbase course 10 cm + Base course            | 50             | 43.98   | 131.578,95 |
| 9  | Subgrade + Subbase course 15 cm + Base course            | 55             | 53,65   | 147.058,82 |
| 10 | Subgrade + Subbase course 20 cm + Base course            | 60             | 55.09   | 151.515,15 |

Table 2 shows that the combination of a 15 cm subgrade + subbase course that has a kv value of 26.83% higher than the kv value of a subgrade + base course combination layer. The same thing happened to the combination of subgrade + subbase course 20 cm which has a kv value of 20.51% higher than the kv value of the subgrade layer + subbase course 5 cm + base course. The relationship between subbase course thickness on plate deflection, CBR and kv.

![Figure 3](image_url)  
**Figure 3** The Plate deflection that occurred in each layer of subbase course

Figure 3 shows the Plate deflection that occurred in each layer of subbase course (without base course) decreased consecutively by 8.06%; 28.07% and 4.88%. Plate deflection that occurred in each layer of the base course has decreased consecutively by 9.62%; 19.15%; 10.53% and 2.94%.

![Figure 4](image_url)  
**Figure 4** Relationship between subbase course thickness and CBR value

Figure 4 shows that the CBR values in each layer of subbase course (without base course) increased respectively by 15.93%; 38.73% and 3.35%. The CBR value in each base course layer increased by 4.63%; 34.09%; 21.99% and 2.68%.

![Figure 5](image_url)  
**Figure 5** the value of kv in each layer of subbase course (without base course)
Figure 5 shows the value of $k_v$ in each layer of subbase course (without base course) increases respectively by 8.77%; 39.02% and 5.13%. The value of $k_v$ in each base course layer increased by 10.64%; 23.68%; 11.76% and 3.03%.

5. Conclusion
The conclusions obtained from this study are:

a. The addition of subbase course thickness of 10 cm to 15 cm can reduce plate deflection values by 28.07% in layers without base course and 19.15% in layers with base course. The $CBR$ value by 38.73% in layers without a base course and 34.09% in layers with a base course. The $k_v$ value increase by 39.02% for layers without base course and 23.68% for layers with base course.

b. The subgrade combination (25 cm) + subbase course (15 cm) has a $k_v$ value of 33.33% greater than the subgrade combination (25 cm) + base course (15 cm). Limestone material can be an alternative to be used as a subbase course layer.

6. Acknowledgment
The researcher wants to support Kadiri University, especially the Engineering Faculty, for giving a chance for doing the research and composing the report.

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