Effects of abaca fiber additives for cold emulsion asphalt mixture

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Abstract. Airport network and Commercial Flight Service network need to be planned and assessed periodically. The planning must be developed based on the Air Passenger Demand prediction. Direct Trip Distribution Model seems the most appropriate for this prediction. Direct Gravity Trip Distribution model was tried to be developed, calculated by using the iterative method. The research gives an indication that the Direct Gravity Trip Distribution can be developed and used. The general formula has been developed. The appropriate formula variables, incorporating the attraction coefficient, the attraction mass, the impedance and its powering value still need to investigate. The calculation method has been developed but needs to be refined, including the optimum and the accuracy indicator. The Direct Gravity Trip Distribution Model can be used either for Air Transport and Sea Transport.

1. Introduction
Asphalt emulsion is a type of bitumen in the form of emulsion at room temperature, with asphalt content composition (60% -70%), water (30% -40%), and emulsifier (0.2% -0.50%). Asphalt emulsion has a low viscosity level so that it can be directly used or mixed with rock without heating first. In addition to being cost-effective (without heating), Cold Emulsion Asphalt Mixture (CAED) in the implementation is easy and environmentally friendly. These are the advantages. Energy for CAED ranges between 40-60% of the energy required to produce hot asphalt mixtures [1]. In addition to having advantages, CAED also has some disadvantages, among others is it takes a long time to increase its strength (due to evaporation of water content), less strong at early age and has a high porosity, resulting from reduced workability during compaction. CAED is suitable for use in tropical climates because it will more quickly increase its strength after compaction, resulting from the evaporation of water content in it.

Crack is a type of damage/failure that occurs in the surface layer of the road caused by deflection and moments affected by some parameters such as excessive load, material properties, environmental conditions, and others. As a result, the continuous excessive load will accelerate the failure of the structure of the road before life is used up (early damage). The weakness of this surface layer can be fixed one of them is by increasing stability, that is, by adding fibre. The fiber that can be used to improve the stability of this surface layer is abaca banana fiber, because it is the superior fiber and the strongest of all natural fibers with high tensile strength, folding strength, buoyancy, high porosity, resistance to saltwater damage [2]. If an abaca banana fiber concrete gives optimal contribution for modulus rupture concrete is in mixture composition 0.25% fiber from the weight of concrete with a two - inch fiber length whose ability of modulus of cracked concrete is equal to 15%. It also provides
an 8% increase in concrete compressive strength with fiber over a mixture of unconfined concrete. The addition of fiber in concrete significantly alters the energy absorption capacity and also contributes to a 39% increase of energy in the cracked concrete. In addition, the associated fiber effect with load and deflection increases bending by 21%, then the addition of abaca banana fiber into cold emulsion asphalt mixture will give an increase to its stability.

The purpose of this study was to analyse the effect of abaca fiber on the stability of cold emulsion asphalt mixture.

2. Theoretical bases

2.1. Design procedure of cold emulsion asphalt mixture

The Determination of aggregate gradation and aggregate proportion of curve modification formula fuller [3].

\[
P = \frac{(100-F)(Xd^{n-0.075^n})}{D^{n-0.075^n}} + F
\]

In equation 1, where P is% the material passes the sieve, d is the size of the sieve, D is the aggregate diameter, F is the filler%, n is the exponential value.

Estimated initial emulsion bitumen content (Book 5. Directorate General of Highways).

\[
P = (0.05A + 0.1B + 0.5C) \times (0.7)
\]

In equation 2, where P is the% of initial emulsion asphalt content, A is coarse aggregate%, B is the fine aggregate%, C is the filler%, then the estimated Emulsion Asphalt Level (KAE).

\[
\text{KAE away} = \frac{P}{X} \%
\]

In equation 3, P is the% of the initial emulsion asphalt level, X is the% emulsion asphalt residue level.

Coating test, this test is carried out by using dry aggregate which has been proportioned according to the graduation, then moistened evenly with some variation of water content (to facilitate the aggregate surface with emulsion asphalt) where water acts as a viscosity reducing agent viscosity of emulsion asphalt) [4]. After that, the moist aggregate is mixed with the emulsion asphalt. The blanket rate is affected by the moisture level of the aggregate. The optimum water content for this test, taken on the smallest water content variations that provide the best visually observed blanket, where the mixture is not too dilute or stiff.

Preparation of the mixing and determination of formula compaction energy

\[
Dd = \frac{(100+RBC)}{(100+RBC+w) \times D}
\]

In equation 4, Dd is the dry bulk density, RBC is the residual bitumen content, w is the moisture content during testing, D is the density bulk during testing (still wet), further porosity formula

Variation of residual asphalt content, based on the determination of the compaction energy giving porosity (VIM) and Marshall Stability value of the bath according to the specified specification, the specimen was prepared with some variation of residual asphalt content. Usually made variations with 0.5% difference as many as two variations below and two variations above the initial residual asphalt content.

Curing specimens, Specimens of the curing process A are immersed in a water bath containing rough sandbags. The specimens were soaked half-height for 24 hours, then reversed and soaked again for 24 hours. Dry with a cloth or suction paper and then weigh for water absorption testing after immersion. Specimens from the B curing process were tested for obtaining water absorption and immersion stability.

Marshall modification testing. Marshall Modification Test is a Marshall stability test carried out at room temperature for the CAED test [5]. While testing the standard marshall for hot asphalt mixture, the sample was conditioned at 60 °C for + 30 minutes before being tested.
Determination of Optimum Residual Asphalt Residue (KARO). KARO was determined by optimizing two parameters namely the stability of immersion and dry bulk density. Other parameters such as porosity, water absorption, and film thickness are evaluated according to the specification, which the KARO value of these parameters must meet.

Asphalt Film Thickness is obtained by multiplying the percentage of culminating passes of each sieve with the surface area factor [6]. Furthermore, TFA is calculated by the formula:

\[
TFA = \left(\frac{\% \text{Asphalt}}{100-\% \text{Asphalt}}\right) \times \frac{1}{\text{SG Asphalt}} \times \frac{1}{\text{Total area of Aggregate}}
\]

Determination of Retained Stability (Retained Stability), is the ratio between the stability of immersion to dry stability with requirement > 50% from Residual Asphalt Residue Level 11. The ultimate strength of CAED, to obtain ultimate strength, the CAED sample is sterilized in an oven at 40°C until the water content evaporates (full curing). The sample can be said in full curing conditions when the weight is constant.

2.2. Abaca fiber (moses textillis nee)

Abaca fiber (moses textillis nee), is a plant belonging to the natural family Musacease (banana plant) originating from the Philippines that has been known and has been developed since 1519. Abaca banana plant is categorized as a male banana, because this banana, does not produce fruit. The main production of this banana cultivation is in the form of fiber (fiber) which is famous in international trade as high quality fiber, because Abaca banana fiber is resistant to salt water and so widely used as wrapping underwater cable or rope on the ship, also for raw materials of high-quality paper pulp such as cash money, checks, filter paper, and wrapping paper.

![Abaca fiber](image)

**Figure 1.** Abaca fiber.

**Table 1.** Physical properties of fiber.

| Physical properties | Abaca | Hemp | Jute | Sisal | Linen | Cotton |
|---------------------|-------|------|------|-------|-------|--------|
| Density (g/cm³)     | 1.5   | 1.48 | 1.46 | 1.33  | 1.4   | 1.54   |
| Fiber length (meter)| 2-4   | 1-2  | 3-3.5| 1     | Up to 0.90 | 0.10-0.65 |
| Fiber diameter (microns) | 150-260 | 16-50 | 60-110 | 100-300 | 12-60 | 11-22 |
| Tensile strength (N/ m²) | 980 | 550-900 | 400-800 | 600-700 | 800 | 400 |
| Elongation (%)      | 1.1   | 1.6  | 1.8  | 4.3   | 2.7-3.5 | 3-10   |
| Moisture regain(%)  | 5.81  | 12   | 13.75| 11    | 10-12  | 8.5    |
| Young’s modulus (GPa)| 41   | 30-60| 20-25| 17-22 | 50-70  | 6-10   |
3. Research methodology

The type of research conducted is an experimental study in the laboratory based on the purpose of research that is Marshall characteristic test, the result becomes a reference in the manufacture of test specimens in the test.

3.1. The composition of abaca fibers as ingredients added to the cold emulsion asphalt mixture.

Variation in the composition of abaca fibers in cold emulsion asphalt mixture consists of 6 different variations of the mixture with different amounts of fiber ranging from 0% (without fiber), 0.1%; 0.15%; 0.2%; 0.25%; 0.3% of the total weight of the mixture with a fiber length of 1" (2.5 cm) refers to research that conducted on concrete with abaca fiber as an ingredient added [7]. The number of variants for the mixture of cold emulsion asphalt added with abaca fiber are 12 variants, namely 6 variants without fiber and without immersion and 6 variants with fiber also with and without soaking. (1 variant 5 test object, a total of 60 specimens) and carried out at room temperature.

3.2. Manufacture and testing of test items.

Making test specimens refers to SNI Marshall begins with aggregate weighing, emulsion asphalt, and abaca fibers. All materials are mixed at room temperature, then put into the cylinder mold that has been coated with filter paper on both sides. Then the compaction process at room temperature was carried out with a pounder (weight 4.5 kg and fall height 45.7 cm) with a number of collisions 50 times for each field of the test object. After that, the test object is left in the mold for 1x24 hours and removed from the mold using an ejector. Then the test object is the oven for 1x24 hours at 38 °C. Furthermore, the specimens with treatments without soaking were tested to determine the characteristics of Marshall using Marshall equipment [8]. While the test object with immersion treatment was carried out the soaking process for 2x2x24 hours to find out the Marshall character.

![Figure 2. The process of making and testing specimens.](image-url)
4. Experimental and discussion results
The material composition is available in table 2 below. The table shows the percentage of abaca fiber, asphalt emulsion, residue, crushed stone and total ash.

| Abaca Fiber (%) | Asphalt Emulsion (8.8%) 105.6gr Residue (62.35%) 65.84 gr | Abaca Fiber (gr) | Filler (gr) | Crushed Stone 1-2 gr | Crushed Stone 0.5-1 gr | Stone Ash (gr) | Total (gr) |
|-----------------|------------------------------------------------------------|------------------|-------------|----------------------|------------------------|----------------|-----------|
| 0               | 105.6                                                      | 0                | 20.68       | 207.94               | 393.98                 | 471.8         | 1200      |
| 0.1             | 105.6                                                      | 1.2              | 19.48       | 207.94               | 393.98                 | 471.8         | 1200      |
| 0.15            | 105.6                                                      | 1.8              | 18.88       | 207.94               | 393.98                 | 471.8         | 1200      |
| 0.2             | 105.6                                                      | 2.4              | 18.28       | 207.94               | 393.98                 | 471.8         | 1200      |
| 0.25            | 105.6                                                      | 3                | 17.68       | 207.94               | 393.98                 | 471.8         | 1200      |
| 0.3             | 105.6                                                      | 3.6              | 17.08       | 207.94               | 393.98                 | 471.8         | 1200      |

4.1. Results of examination of Marshall characteristics of asphalt mixture AC-WC emulsion.
Table 3. Recapitulation of stability parameter test results (Marshall Test) with treatment without immersion and hammer blows 2x50.

| Content Abaca (%) | Stabilities (kg) | Flow (mm) | MQ (kg/mm) |
|-------------------|------------------|-----------|------------|
| 0                 | 1064             | 3,87      | 274,7      |
| 0.1               | 1358,78          | 3,81      | 357,02     |
| 0,15              | 1435,6           | 3,74      | 383,85     |
| 0.2               | 1776,49          | 3,61      | 491,84     |
| 0.25              | 1536,43          | 3,71      | 413,8      |
| 0.3               | 1268,89          | 3,78      | 335,85     |

4.2. Relationship of fiber abaca with stability
Based on the Marshall test results, the relationship between the Abaca. Abaca content and the stability with the soaking treatment is shown in fig.3
The stability value obtained meets all the specifications set by DGH, i.e., higher or equal to 450 kg.

4.3. Relationship of fiber abaca with flow
Based on the Marshall test results, the relationship between the Abaca content and the flow with the soaking treatment is shown in Fig. 4.

4.4. Relationship of fiber abaca with Marshall quotient (MQ)
Based on the Marshall test results, the relationship between the Abaca content and the MQ with the soaking treatment is shown in Fig. 5.
Figure 5. Relationship of Fiber Abaca with Flow.

5. Conclusion
The optimum stability for cold emulsion asphalt mixture with abaca fiber added material without immersion is at 2% fiber volume of total weight.

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