SIMPLE TECHNOLOGY OF SOIL STABILIZATION

Hermin Tjahyati

RINGKASAN :

Stabilisasi tanah dengan menggunakan peralatan sederhana dapat dilakukan secara padat karya, dan saat ini diperlukan terutama pada jalan-jalan berlalu-lintas rendah yang masih memerlukan jalan keras tak beraspal selain yang dibuat dengan hamparan batu pondasi Macadam maupun sistim Telford. Dengan cara ini cukup tenaga pekerja dengan cangkul dan alat pemadat PVR 1 ton, maka bila dilakukan sesuai dengan petunjuk teknis seperti yang tertulis dalam tulisan ini , dapat diperoleh hasil yang maksimal sesuai dengan disain laboratorium. Dari percobaan yang dibuat di beberapa daerah pada tahun 1996 cara ini cukup kompetitif, dapat dilihat dari biaya (1996) terutama pada daerah yang sulit untuk mendapat batuan dibandingkan dengan Macadam atau Telford..

SUMMARY :

Simple technology of Soil stabilization as a labour intensive methods is very effective for low traffic rural roads when unpaved roads is to be needed, beside Macadam or Telford system.
According to the guidance in this paper , a group of workers with hoe and 1 ton of PVR compaction, can be produced appropriate road pavement of soil stabilization using cement or lime or another chemical agent as a stabilisator of the mixtures related to the laboratory design mixture.
The cost of this soil stabilization methods in 1996 is competitive enough than another labour intensive method such as Macadam or Telford, actually, in the scarce area of stones.

I. INTRODUCTION

70% of district roads in Indonesia have traffic levels below 200 vehicles per day. Traditionally the roads are constructed mostly using Telford tehcnique.Large stones are embedded into the ground,the gaps filled with progressively smaller stone and the whole structure stabilized with bitumen.
An alternative, low cost construction technique is proposed soil stabilization. This would provide reliable all weather acces,for traffic levels belows 100 vpd. And at the same time conserve scarce or expensive aggregates.

In the comparison of the cost with another type of non-bituminous roads, the stabilization of suitable road subgrade materials significantly reduces the demand for and conserves costly and often scarce high quality pavement aggregates.
The cost of transport demand to site is greatly reduced. For example :100 metres of roads in 3.50 metres in width and 20cm thickness, when its stabilized with 6% cement need 130 bags @ 40kg and it can be 1 loaded of truck.If that roads use agregate as a base material in the same thicknesess, 70 m3 of agregates must be prepared, it will be needed 10 trucks @ 7 m3.
So one load of cement or lime being equivalent of about 9 to 10 loads of aggregate.
This has added the benefit of reducing heavy traffic on site and acces roads to site thus reducing maintenance costs.

This report is a guidance for cement and lime soil stabilization. If properly applied, the results can be impressive.
Institute of Road Engineering, in colaboration with International Labour Organization (ILO) project has been applied this methods in Subang, using 8% of lime to the heavy clays of subgrade an it can be improved from CBR = 3% to CBR = 30%. In Pontianak, lateritics soil subgrade can be improved using 5% of cement from CBR = 6% to CBR = 65%,where for low traffic road we only need improving subgrade to the CBR $\geq$ 25%.

When the traffic increase in the future, this soil stabilization pavement can be improved to bituminous standards would therefore require no subbase aggregate and reduced thickness of base course aggregate layer.

II. OBJECTIVES

The objective of this manual is to give guidance for the construction of low traffic roads (< 100 vpd total) using lime and cement stabilization .

III. METHODOLOGY

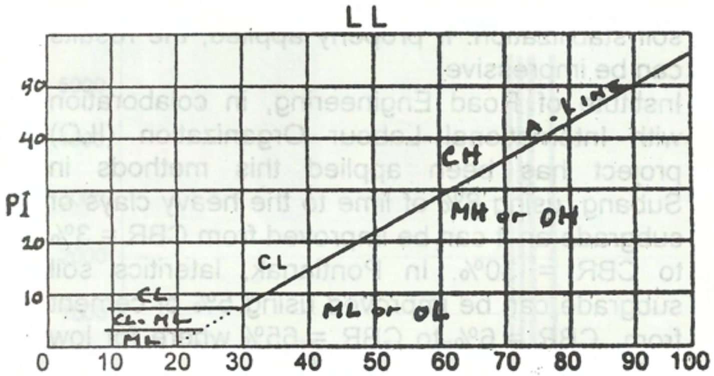
A procedure is given, commencing with the laboratory testing of the materials, through to mix design and field implementation.

For Indonesia, it is suitable for district/rural roads and is aimed at maximising the use of local materials of probable substandars quality, low cost manual labour and cheep equipment.

III. MATERIAL TESTING

Soil testing is first necessary classify to the soil and determine which stabilization agent is required to improve the soil characteristics. The favourable of the lime or cement to the soil will perform soil stabilization pavement as an anticipated result design.
The chart below is a plot of liquid limit (the moisture content of the soil at wich it has little shear strength).

CL = low plasticity of clay
CH = high plasticity of clay
MH = high plasticity of silt
ML = low plasticity of silt
OH = high plasticity of organic soil
OL = low plasticity of organic soil



Plasticity chart

If the condition of the soil is CL, stabilization using cement will be more effective than lime. Lime stabilization will be more effective than cement for CH soil condition.

3.1. Material testing for soil stabilization purposes

Before field implementation, soil testing of the materials is necessary to identify :

- liquid limits
- type of stabilization agent
- the quantity of stabilization agent
- degree of compaction.

3.2. Soil classification

Soil classification should be done based on the Unified Soils Classification System as follows :

- Particle size distribution SNI 03 - 1986 - 1990/ASTM D 422 - 63(74)
- Liquid Limit SNI 03 - 1967 - 1990/ASTM D 423 - 66(72)
- Plastic Limit SNI 03 - 1966 - 1990/ASTM D 424 - 59(72)
- Soil Classification ASTM D 2487 - 69(75)

3.2.1. Soil Strength :

- Soil Compaction test / Moisture density relationship SNI 03 - 1742Ä1989/ASTM D 558 - 1976
- Capacity bearing ratio SNI 03 - 1744 - 1989/ASTM D 1883 - 73
- Specific gravity SNI 03 - 1964 - 1990/ASTM D 854 - 58(74)
- Unconfined Compressive Strength SNI 03 - 3637 - 1994/ASTM D 2166 - 66(79)

3.2.2. Test for Cement or Lime mixture design :
Cement and lime mixture design can be done in the laboratory using the guidance of SNI 03 - 3437 - 1994 for lime and SNI 03 - 3439 - 1994 for cement.
In this guidance several tests should be done as follows :

- Liquid limit
- Plastic limit
- Standard proctor compaction
- California Bearing Ratio
- Unconfined Compressive Strength

The target of CBR for subgrade of district low traffic roads in Indonesia in the general condition is CBR > 24%.

3.3. Material testing during Field implementation

The pavement could be made from material excavated from the side of the road, and having a suitable drainage ditch. The materials should be tested/checked to see if they can be stabilized satisfactory otherwise other materials must be imported.

After the camber layer already finished, the judgement of optimum moisture content of the camber layer material should be done.
Add water if the pavement layer materials too dry.

Fresh cement or lime must be used and material older than 6 months should not generally be used.

Cement or lime must be mixed well with the chosen materials at or slightly above the Optimum Moisture Content. Compaction should be done with 3 hours of mixing for cement or within 2 days for lime after stabilization OMC goes up. After compaction moisture content and density should be tested to confirm the available condition using speedymeter and sandcone test.

3.4. Material testing after field implementation

Material testing consisting of CBR and density (sand cone) should be undertaken on the stabilized layer 7 days after compaction of works at every 50 mtr to 100 mtr interval along the roads.

IV. CONSTRUCTION TECHNIQUE

A construction technique is discussed below, suitable for labour intensive methods.

4.1. Equipment and optimizing

Common simple equipment for this technology is listed below :

- Hoe
- Shovel
- Pick
- Mattock
- Cutter mattock
- Spreader rake
- Fork rake
- Sledge hammer
- Wheel barrow
- Watering can
- Vibro baby roller

4.2. Labour capacity

A group of 16 labourers should be sufficient for spreading, mixing, making a pavement of 25 loose soil layer, 4mtr road width and 25 mtr length for 3 hours.

4.3. Working Method

Step 1 :
Pole and rope are installed along the centreline of 25 mtr of pavement layer shown in fig. 1A and 1B.

fig. 1A
CAMBER OF PAVEMENT LAYER

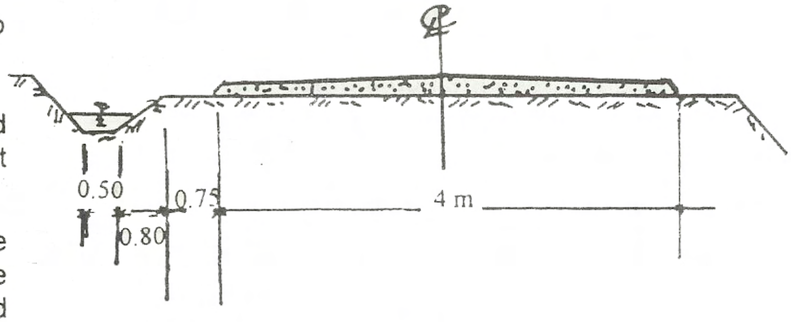
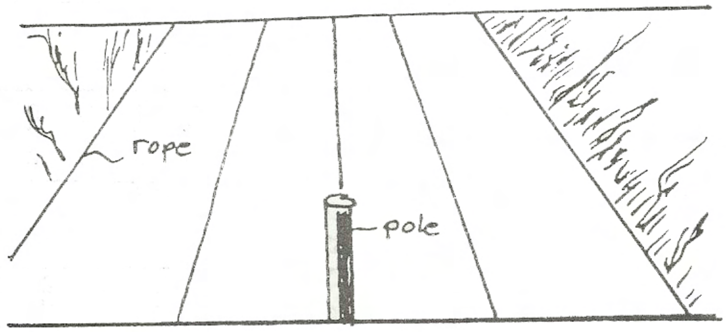


fig 1B.
INSTALLATION OF POLES



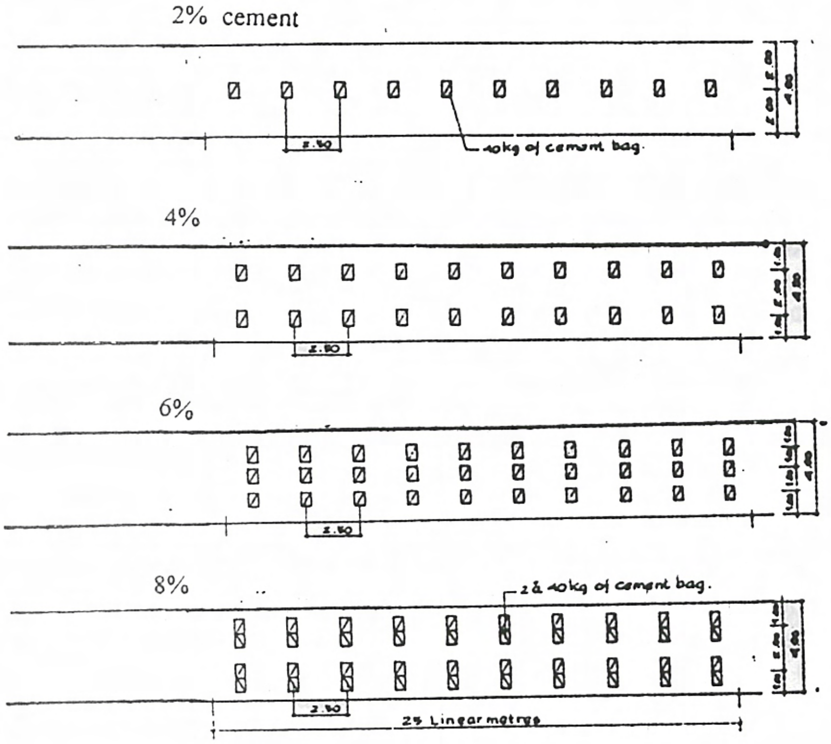
Installation of the poles should be carefully done to direct the labourers to put the cement bag on the pavement layer in the correct proportions.
The quantity of 40 kg cement/lime bags for a 4 mtr width,25 mtr length of roads and 25 cm loose soil is shown in table 1.

% of cement or lime	total cement bag (40kg) for 25 mtr of road
2	10
4	20
6	30
8	40
10	50

Step 2 :
The soil moisture content of camber layer should be tested before cement spreading. Add water using watering can if the soil too dry to achieve optimum moisture content.
Allow to dry if too wet. Optimum moisture content judgment is very important before mixing.

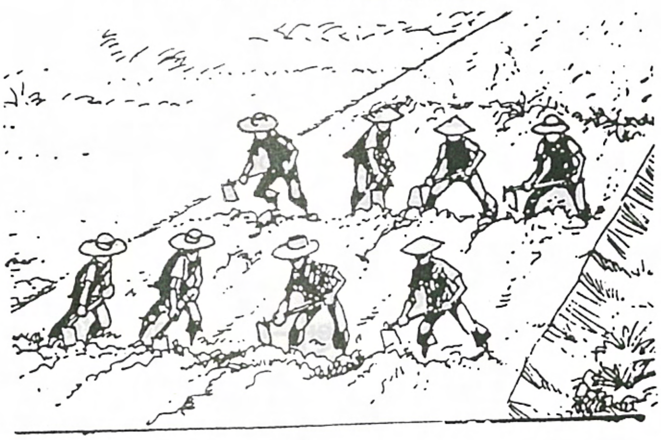
Step 3 :
When pole and rope is finished and optimum moisture content has been achieved, a profile should be made to board measure the length between every cement bag on the pavement layer, shown in fig. 2 :

Fig. 2.
CEMENT BAG ON THE PAVEMENT



Step 4 :
Pulverize the pavement layer before cement/lime mixing using 8 to 12 labourers.This is necessary to assist homogeneuos mixing of the stabiliser afterward. This is shown in fig.3. below,

Fig. 3.
SOIL PULVERIZATION



Step 5 :
During the pulverization,another 8 labourers must bring cement bags using wheel barrow and put then down on the surface of the pavement according to the step. 3

Step 6 :
Open cement bag and spread cement carefully on the pulverized pavement layer using a spreader rake. This is illustrated in fig.4 and fig. 5

fig. 4.
SPREAD CEMENT FROM CEMENT BAG

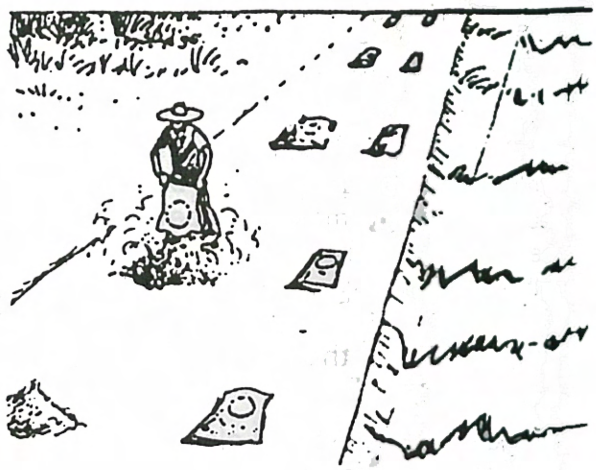
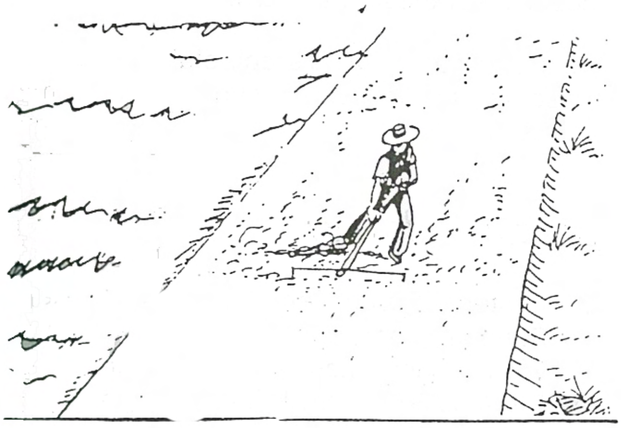
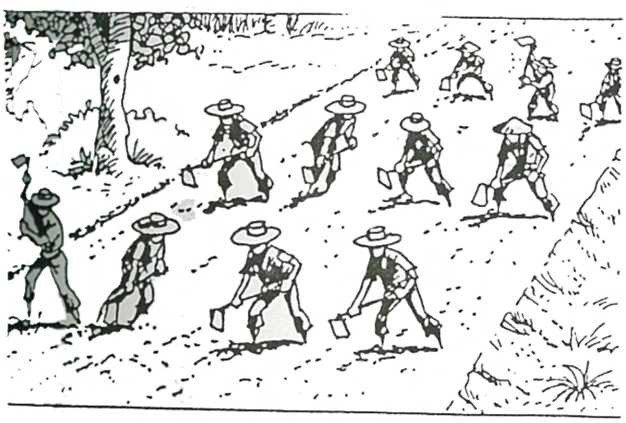


fig. 5.
SPREADER RAKE TO SPREAD CEMENT OVER ALL THE SURFACE



Step 7 :
Soil cement mixing can be done using 16 labours. These groups should be divided into rows of 4 x 4 with 5 mtr in between.
The first row of 4 labours start mixing at the beginning of the road section. After 5 minutes,or when the first row 5mtr forward the second row starts mixing at the beginning of road section.
The process is repetead for the third row. The four rows of labourers should continue mixing untill the end of the 25 mtr section. The whole operation should be completed at least twice within 2 hours if cement is used.
According to the empirical methods in Kalimantan and in Bandung, 6 cycles is enough.
The mixing can be shown in fig. 6

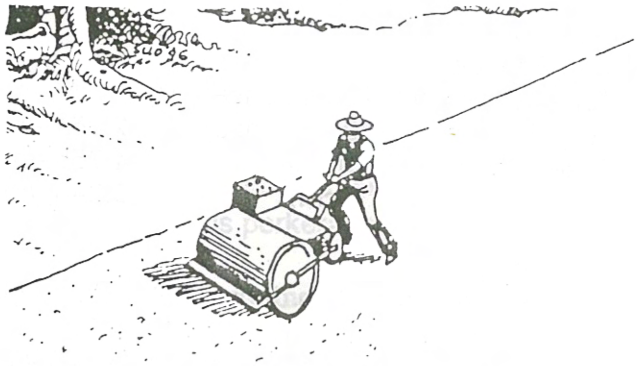
fig.6 .
SOIL - CEMENT / LIME MIXING



Step 8 :
When these groups have finished the mixing,they should then form the road camber of around 5% before compaction. The angle can be ajusted by visual of sense.

Step 9 :
The camber layer shoul be compacted using 1 tone PVR. At least 20 passes should made over all the surface, until 95% of the maximum dry density for the cement content used is achieved. Laboratory test.

Fig.7.
COMPACTING USING VIBROROLLER



If cement stabilizer is used, step 6 to 9 should be finished within 2 hours. If lime stabilizer is used, more time is possible but generally no more than 48 hours shoul be allowed.

Step 10 :
Cover the compacted pavement layer of cement or lime stabilization using plastic sheet or alternatively wet sand or asphalt, and allow 7 days for curing. During this time no traffic should be allowed to pass over the pavement layer because it is gaining strength.

To enable traffic to continue to pass, either only half side, the stabilised layer should be considered or temporary road should be constructed .

4.4. Summary of Main Point.

- At least 16 labours + 1 labour PVR operator should be provided.
- The soil of the layer must be pulverised well.
- Moisture content should be checked before and during mixing
- Spreading and mixing soil cement homogeneously
- % 5 of slope angle of the camber layer to the sideways
- The day - to - day of field works should be finished after compacting.

V. COST

The estimated costs for road construction using soil stabilization using local materials are quoted below are based on the experience and the crushed rock road base materials information was supplied by contractors.

Items included in the cost analysis of stabilization are the cost of the labourers and the cement. The soil can be found at the location. For crushed rock, the cost include cost of the labourers and the stone.

For example (in '1996) :

1. In Bandung

Soil - 6% cement	(20cm dense)	Rp 6.195,-/m2
Soil - 8% lime	(20cm dense)	2.864,-/m2
Base (stone)	(10cm)	4.755,-/m2
Subbase (stone)	(10cm)	5.248,-/m2

2. In Pontianak

Soil - 6% cement	(20cm dense)	Rp 9.300,-/m2
Base (stone)	(10cm)	4.275,-/m2
Subbase (stone)	(10cm)	5.275,-/m2

In Bandung the cost of 20 cm of soil cement stabilization is cheeper than 20 cm of (10 cm subbase + 10 cm base) of stone. In Pontianak soil cement stabilization and rock road base, both are in the same value.

Costs of cement and lime vary greatly throughout Indonesia, depending on the distance from work place to lime/cement manufacturing facility. The feasibility of cement/lime stabilization depend greatly on the local cost of these materials.

Field application of this soil stabilization will be presented in the next edition of this Journal on August 1998.

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Penulis :

Ir. Hermin Tjahyati, Msc, Peneliti Muda Bidang Geoteknik Jalan, Pusat Litbang Jalan

DAFTAR JUDUL RANCANGAN STANDAR NASIONAL INDONESIA (R SNI) BIDANG JALAN HASIL PANTAP 1997 / 1998

NO.	JUDUL	RUANG LINGKUP
1.	Metode Pengujian Kandungan Bahan Anorganik - atau Abu dalam Aspal.	Metode ini dimaksudkan untuk menentukan kandungan bahan mineral dalam aspal padat, semi padat atau cair.
2.	Pedoman Pemilihan dan Penggunaan Aspal Emulsi.	Pedoman ini meliputi pemilihan dan penggunaan aspal emulsi untuk berbagai jenis perkerasan.
3.	Metode Pengujian untuk Menentukan Tingkat Kepadatan Perkerasan Beraspal.	Metode pengujian ini menjelaskan prosedur untuk menentukan tingkat kepadatan perkerasan beraspal yang dibandingkan terhadap benda uji standar dari material yang sama dan berada dalam toleransi perencanaan campuran
4.	Spesifikasi Kapur untuk Campuran Beraspal.	Spesifikasi ini meliputi dua tipe kapur yang digunakan untuk mengurangi pengaruh air yang terdapat dalam campuran beraspal.
5.	Metode Pengujian untuk Penentuan Kadar Serat dari Contoh Gambut dengan Cara Kering di Laboratorium.	Metode pengujian ini meliputi penentuan kadar serat dari contoh gambut (sesuai dengan pengertian klasifikasi gambut dalam ASTM D. 4427). Pengujian ini dapat pula digunakan untuk tanah organik bukan gambut.
6.	Metode Pengujian Kadar Air, Kadar Abu, Bahan Organik dari Tanah Gambut dan Tanah Organik Lainnya.	Metode pengujian meliputi penentuan kadar air, kadar abu, dan bahan organik dalam tanah gambut serta tanah organik lainnya seperti lempung organik, lanau dan lumpur.
7.	Metode Pengujian Kekentalan Graut untuk Beton Agregat Praletak (Metode Pengujian Corong Alir).	Metode ini meliputi prosedur, yang dapat digunakan di laboratorium dan lapangan, untuk menentukan waktu alir dari volume cairan graut semen hidrolis yang ditentukan melalui corong alir standar dan digunakan untuk beton agregat praletak. Metode pengujian ini dapat juga digunakan untuk graut lainnya.
8.	Metode Pengujian Kemampuan Mempertahankan Air Pada Campuran Graut untuk Beton Agregat Praletak di laboratorium.	Metode pengujian ini meliputi prosedur untuk menentukan kemampuan mempertahankan air dari campuran graut semen hidrolis segar untuk beton agregat praletak.