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RECOMMENDED PRACTICE
FOR
THE PULVERIZATION
OF
BLACK COTTON SOILS
FOR
LIME STABILISATION

THE INDIAN ROADS CONGRESS

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1. INTRODUCTION

1.1. Stabilising black cotton soils with lime has been found to be an effective method to improve their engineering properties. This technique is finding increasing application in black cotton soil areas for the construction of sub-bases of road pavements.

1.2. Black cotton soil is characterised by high swelling when wet and excessive shrinkage when dry. This poses problems as regards subsequent performance of the road. Moreover, the softened subgrade has a tendency to work up into the upper layers of the pavement, especially when the sub-base consists of stone soling with lot of voids. Gradual intrusion of soil invariably leads to failure of the road. Such difficulties could be avoided by providing a sub-base layer of granular material or of lime-stabilised soil which would serve as a blanket course between the subgrade soil and the upper layers of the pavement.

1.3. A pre-requisite to successful lime stabilisation is that at the time of addition of stabiliser, the soil should be in a reasonably pulverised state. Whereas light textured soils are generally friable, and therefore easy to pulverise, this is not so in the case of expansive soils like black cotton soils, which are soft and sticky when wet but very hard when dry. Besides affecting the uniform mixing of lime, the degree of pulverisation influences the amount of lime necessary to achieve the desired gain in strength.

1.4. Realising the importance of pulverisation in the case of black cotton soils, this Standard was initially prepared by the Soil Engineering Committee (personnel given below) for general guidance in this respect. It was processed and approved by the Specifications

and Standards Committee in their meeting held on the 29th and 30th September 1972. Later, this was finally approved by the Executive Committee in their meeting held on the 11th March 1973 and by the Council in their 81st meeting held at Cochin on the 26th April 1973.

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2. SCOPE

2.1. The Recommended Practice applies both to construction of new roads and widening of existing roads. It covers pulverisation by manual means as well as with mechanical equipment.

2.2. Pulverisation may be carried out either at borrow source, or at embankment site after deposition of the soil, depending on feasibility and convenience.

3. DEGREE OF PULVERISATION

3.1. Degree of pulverisation has a profound effect on the properties of lime-mixed black cotton soil. This would be clear from the illustrative example given in *Annexure 1.*

3.2. Pending further research, pulverisation to the following degree should be aimed at in the field :

Sieve designation (IS : 460)	*Per cent by weight of soil passing the sieve after pulverisation*
25 mm	100
4.75 mm	50

3.3. Method of sieving to determine the degree of pulverisation should be as given in *Annexure 2.*

4. METHODS OF PULVERISATION

4.1. Using Manual Labour

4.1.1. This method can be best used in summer months when the soil is dry. Top vegetation is removed and dry soil crust loosened to a depth of about 20 cm with the help of crow-bars. Bigger sized clods can be further broken down with pick-axes or rammers. Application of a country plough driven by a bullock can also be tried, which proves sometimes effective.

4.1.2. Alternatively, the soil dug from the field can be stacked and water sprinkled on it. After allowing some time for the soil to dry, water should be sprinkled again. This procedure is repeated sufficiently so as to lead to a gradual disintegration of the soil clods at the surface thereby reducing their size. But the process is slow and workable only in areas where water is within economic reach.

4.2. Using Power Rollers

4.2.1. This method can be used only when the soil is dry. The soil is dug from the field and clods broken with pick-axes so as to reduce them to a maximum size of 5 cm. Soil clods are spread over the subgrade and a smooth wheeled 8 tonne power roller passed over them a number of times, accompanied by frequent raking of the crushed material. About 8 passes of the roller combined with raking should normally be able to achieve the required degree of pulverisation.

4.3. Using Heavy Agricultural Machinery

4.3.1. The following mix-in-place plant can be effectively utilised for pulverisation :

(i) Tractors (on chain tracks) of about 110 H.P.;

(ii) Mould Board Ploughs (consisting of four furrows which can plough upto about 40 cm depth);

(iii) Disc Harrows (consisting of five discs of about 70 cm dia, with a working width of 3 metres);

(iv) Off-set Harrows (consisting of 18 discs of about 50 cm dia, arranged in two rows with a working width of 3 metres).

4.3.2. The natural ground may be ploughed using a Mould Board Plough attached to a heavy tractor. This should loosen the soil to a depth of about 40 cm. The Mould Board Plough is then replaced by Disc Harrow which is passed over the ploughed soil about four times in order to break down the clods further. The soil is then processed about five times with an Off-set Harrow attached to a tractor. Any big clods still left could be picked out by manual labour.

4.3.3. A moisture content in the range of 15-30 per cent is most appropriate for the use of heavy agricultural machinery. At higher moisture contents the soil tends to be sticky and the implements get bogged down. At lower moisture contents, the soil clods are too dry for effective pulverisation. It follows from this that it would be most advantageous to pulverise soil after the rainy season when appropriate moisture conditions are likely to prevail in the field.

4.4. Using Light Agricultural Machinery

4.4.1. The light machinery could comprise the following :

(i) Tractors of about 50 H.P.

(ii) Mould Board Ploughs (consisting of three furrows)

(iii) Disc Harrows (consisting of 20 saucer shaped discs having a dia of about 25 cm); and

(iv) Off-set Harrows (consisting of 10 discs arranged in 2 rows with a dia of about 50 cm).

4.4.2. The operations are to be carried out in the same way as with the use of heavy machinery. Effective pulverisation is possible in the moisture content range of 18 to 22 per cent. About 6 passes of Disc Harrow and 10 passes of Off-set Harrow would be sufficient to yield an acceptable degree of pulverisation.

4.4.3. The cost with this method works out to be generally more than with heavy machinery. The higher cost with light machinery is due to the fact that the Mould Board Plough fitted to a light tractor cannot plough to a depth of more than 20 cm.

4.4.4. Even though light machinery may prove less economical, its use has the advantage that as compared to heavy machinery, the equipment can be procured more readily either by hiring out from agriculturists or buying it outright from the market.

4.5. Other Variations

4.5.1. As a modification of the methods described in the preceding paragraphs, the soil may be excavated and stacked on the berms, allowed to dry to a moisture content of about 15-20 per cent, relaid on the subgrade in a layer of about 25 cm thickness and its clods broken by dragging a heavy wooden log of 30 cm × 30 cm × 3 m size pulled by a tractor. The soil is then turned upside down with the help of an off-set plough so that no clods remain at the bottom of the layer. Thereafter lime is spread on the pulverised soil layer in required quantities and mixed with the soil by means of an off-set plough resulting in further pulverisation of the soil.

5. PRIOR ADDITION OF LIME TO AID PULVERISATION

5.1. Adding a small quantity of lime to soil, which is already partially broken down to small clods, and allowing it to work in for 3-4 days before final pulverisation, is known to help in achieving a better degree of pulverisation. The moisture content should be sufficient to assist the migration of lime. Detrimental effect of this procedure on soil-lime reaction, due to exposure to air containing carbon dioxide, is very slight inasmuch as the time of exposure is small. Presumably lime reacts with carbon dioxide to form calcium

carbonate, with consequent loss in lime content and strength. It is likely that if this procedure is resorted to, a somewhat greater concentration of lime might be required than if the entire quantity of lime were to be added in a single stage.

5.2. Tentatively, it is recommended that about 50 per cent of the required concentration of lime may be added prior to pulverisation, and the balance after pulverisation. The exact amount of lime to be added initially could be finalised on the basis of tests for the soaked CBR value attainable by this procedure.

5.3. It is suggested that in the field, the clay clods should all be broken down to 5 cm size or lower before lime is added in the pre-pulverisation stage.

Annexure 1

ILLUSTRATIVE EXAMPLE OF THE EFFECT OF DEGREE OF PULVERISATION AND PERCENTAGE ADDITION OF LIME ON PROPERTIES OF BLACK COTTON SOIL

1. Table below shows the effect of degree of pulverisation on soaked CBR of a typical black cotton soil when treated with 3 per cent hydrated commercial lime (of 40 per cent purity) and compacted to a density of 1.5 gm/cc.

TABLE

Sample No.	Per cent passing sieve no.			Soaked CBR	Moisture absorption (per cent)
	IS sieve 25 mm	IS sieve 4.75 mm	IS sieve 2 mm		
1	100	—	—	2.4	27.5
2	100	50	15	14.2	26.3
3	100	100	30	14.3	26.9
4	100	100	100	14.7	25.3

Notes : (a) The values of CBR given above should be regarded as illustrative only.

(b) Curing period for the samples was 10 days.

(c) The soil had LL=75, PI=35 and per cent free swell of 100.5 per cent.

2. It may be inferred from the results above that if soil is so pulverised that at least 50 per cent of it is finer than 4.75 mm sieve, then the strength attained is practically the same regardless of the fraction passing 2 mm sieve. This may be attributed to the fact that in the process of mixing soil with lime, and during its subsequent compaction, the degree of pulverisation increases.

Annexure 2

METHOD OF SIEVING FOR COHESIVE SOILS TO DETERMINE THE DEGREE OF PULVERISATION

1. A sample of pulverised soil, approximately 1 kg in weight, should be taken and weighed (W_1).

2. It should be spread on the sieve and shaken gently, care being taken to break the lumps of soil as little as possible. Weight of soil retained on the sieve should be recorded (W_2). Lumps of finer soils in the retained material should be broken until all the individual particles finer than the aperture size of the sieve are separated.

3. The soil should be again replaced on the sieve and shaken until sieving is complete. The retained material should be weighed (W_3).

4. Per cent weight of soil passing the sieve can then be calculated from the expression :

$$\frac{(W_1 - W_2)\ 100}{(W_1 - W_3)}$$