

USE OF NATURAL RUBBER LATEX TO IMPROVE SEEPAGE RESISTANCE OF SOILS *

By

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INTRODUCTION

Conservation of water by reducing seepage into the soil and losses due to evaporation as well, is one of the major problems in the dry zone of Ceylon. The high costs involved in some of the currently practised methods such as lining irrigation channels with brick and cement and concrete to prevent seepage preclude their use on an extensive scale. The experimental study reported in this paper is a preliminary evaluation of the possibility of using natural rubber (NR) latex to prevent or substantially reduce such seepage losses. The results presented are not intended to represent the end product of a comprehensive study but are rather to be considered as an initial exploration of the potential use of a cheaply available raw material as an economic soil stabilizer against seepage.

A pilot experimental study of the use of NR latex as a binder for soils to improve seepage resistance was undertaken. The selection was based on its suitability for *in situ* soil stabilization. This was evaluated using compression and seepage tests. It was observed that the treated soils out-performed their unmodified counterparts. The ideal sealant against seepage would be one which is cheap, effective, durable and easily applicable.

Work has been reported elsewhere on the use of latices and other polymeric substances to stabilize soils (Fungaroli & Prager, 1969) and also on the use of synthetic latices to improve soil conditions against erosion. NR latex is a cheap raw material available in Ceylon and its usefulness as a soil stabilizer arises from the following facts :—

- (a) Miscibility with water before curing,
 - (b) Immiscibility with water after curing,
 - (c) Low viscosity for ease of mixing and handling,
 - (d) Non-toxicity,
 - (e) Suitability for curing under typical field conditions,
- and (f) Complete compatibility with various soils.

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Wettability and sprayability of NR latex in regard to its consistency:— NR latex has a rather high surface free energy, although some reduction can usually be effected by the addition of surface active substances. One of the practical consequences of a high surface free energy is that it is difficult to induce latices to wet down solid surfaces properly, especially if the surface is greasy. It should be noted that NR latex does offer some distinct advantages in respect of the wetting behaviour. They are able to wet down surfaces which are already wetted with an aqueous medium. This characteristic may be exploited to full advantage in the application of NR latex as a soil stabilizer.

Polymer latices remain fluid up to reasonably high concentrations. Field latex contains on an average about 30% (w/w) of dry rubber and due to the low viscosity spraying of stabilized field latex is not a problem. Moreover, the incorporation of ammonia (approximately 1.0% by weight) into the latex, prevents any localised coagulation of latex within the containers or sprayers, thus rendering it possible for the latex to be sprayed out smoothly.

MATERIALS AND METHODS

The sprayer used in our experiments was a Hortensia sprayer which is commonly used in horticulture. This is a very handy and portable model of a sprayer which could be pressurised initially by means of a detachable inflator unit with the fluid to be sprayed having to be filled into the container of the sprayer before inflating and the actual spraying could then be performed conveniently by manipulating a valve device and directing the spray as required through the outlet tubing, the end of which is fitted with an interchangeable nozzle.

The soil type selected for our experiments was not governed by any specific reasons; the soil type used was a clay loam soil having the following mechanical composition.

These results of mechanical analysis are calculated on a moisture-free basis.

1. Percentage of coarse sand	=	40.32
2. Percentage fine sand	=	13.82
3. Percentage silt	=	6.89
4. Percentage clay	=	28.92
5. Percentage loss on solution (R_2O_3)	=	7.18
6. Percentage organic matter	=	0.69

Two series of tests were performed *viz.* (1) compression tests, and (2) seepage tests.

Compression tests — sample preparation: Three-inch cubes of soil specimens were prepared in a standard mould constructed for the purpose. All test specimens were prepared in the same manner. The soil and latex were first mixed together in varying proportions. In each case after mixing the soil was compacted using a mason's trowel, and prior to testing, the specimens were cured for 16 hr at 100°C.

Testing procedure: The compression test was performed at an axial strain rate of 0.5 in. per minute and the failure load recorded to the nearest pound.

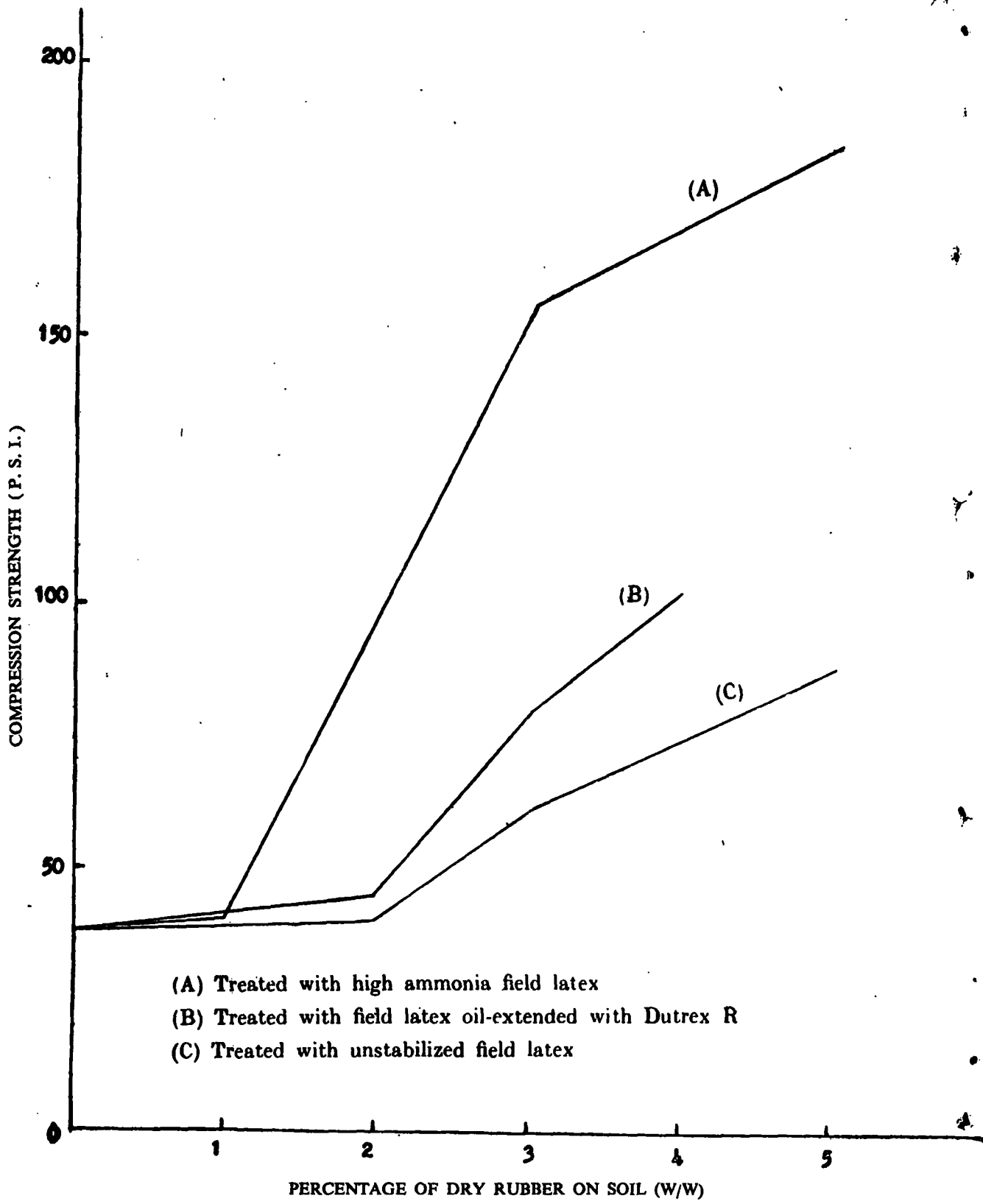
TABLE I
COMPRESSION STRENGTHS OF UNCONFINED SOIL CUBES (3 in.)
STABILIZED WITH NR LATEX

Stabilizer system	% dry rubber based on dry wt of soil	Compression strength in lb per sq in.
Control	nil	38
Field latex	1	—
”	2	40
”	3	67
”	4	—
”	5	89
Field latex oil-extended to 25% with Dutrex R	1	—
”	2	44
”	3	80
”	4	102
”	5	—
Ammoniated field latex	1	40
”	2	89
”	3	156
”	4	169
”	5	176
Sodium hydroxide-stabilized	1	18
”	2	—
”	3	27
”	4	33
”	5	49

Note — All samples were oven-dried at 100°C.

Seepage tests : Field experiments were conducted in order to determine seepage resistivity of different treatments of latex on soil as follows :—

Method of preparation: A series of pits (hereinafter referred to as ‘seepage pits’) 4 ft long, 1 ft wide at the surface and 8 in. wide at the bottom and 6 in. deep with more or less a trapezoidal cross section, in that the banks were slanting towards the median longitudinal axis at the bottom, were dug out. The average surface area of the bottom and sides of each seepage pit was about 7.5 sq ft.



(A) Treated with high ammonia field latex
(B) Treated with field latex oil-extended with Dutrex R
(C) Treated with unstabilized field latex

Fig. 1. Compression strength data on soil stabilized with natural rubber latex

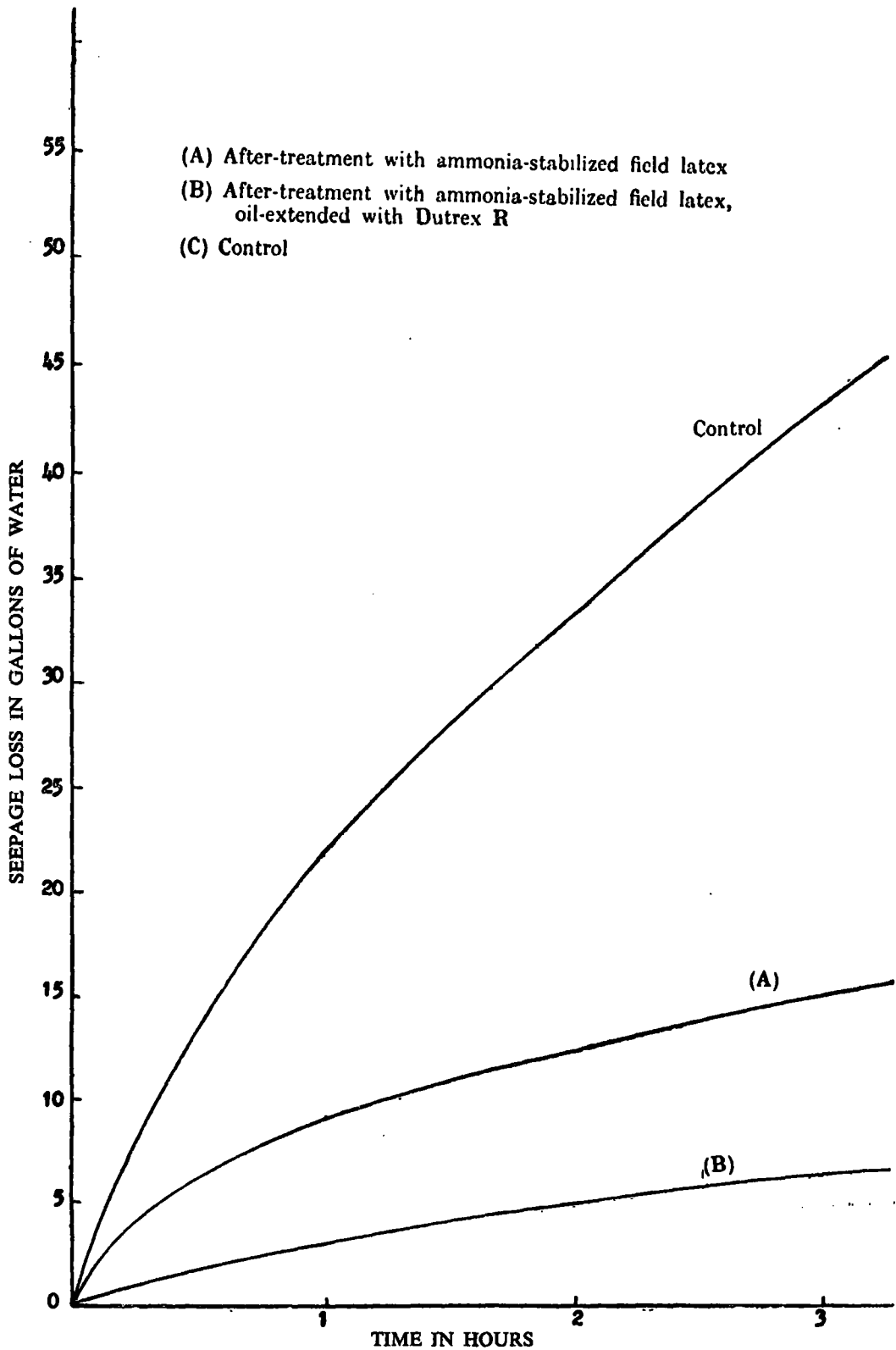


Fig. 2. Effect of stabilizers on soil for the prevention of seepage losses

The seepage pits were treated with different latex mixes. In each case latex was stabilized with 1% ammonia. 1000 ml of the appropriate latex mix was sprayed into each pit; first, about one half of the quantity of the material was evenly sprayed over the seepage pit, allowed to become partially dry, and thereafter the remaining portion of latex sprayed over uniformly as a further coating.

In one treatment Octanol was used as a defoaming agent at the rate of 1.5 parts by weight per hundred parts of dry rubber.

The following are the latex mixes used in each case :—

- (A) Field latex stabilized with 1% NH_3 based on the latex,
- (B) Same as (A), but with Octanol as the defoaming agent,
- (C) Stabilized field latex, oil-extended to 8% by weight on the dry rubber content using Dutrex R,
- (D) Stabilized field latex, oil-extended to 12.5% with Dutrex R,
- (E) Stabilized field latex, oil-extended to 25% with Dutrex R,
- (F) Stabilized field latex, oil-extended to 50% with Dutrex R.

Field latex was used in all these trials and the dry rubber content was about 30%.

Testing procedure: The initial seepage of such a pit, without any surface treatment, was determined in terms of the time taken successively for several $2\frac{1}{2}$ gal quanta of water to seep through completely. At the time of pouring down a $2\frac{1}{2}$ gal quantum of water into the pit, the initial time was noted and after complete seepage the time was noted again, immediately followed by pouring down a further quantum of $2\frac{1}{2}$ gal of water and the time noted as before. This process was repeated until the rate of seepage was apparently constant.

Similar determinations of seepage times were carried out on seepage pits, the surface of which were treated as described above. Measurements were taken one day after surface treatment.

RESULTS

Permeability of latex into the soils: Poor permeability of latex into the soil invariably results in a matty effect on the surface. When the latex is extended with oil the binding effect on the soil particles is greatly improved with reduced mat formation. The binding and sealing effect is improved with increasing oil content up to a maximum of about 25 parts of oil per 100 parts of dry rubber. The tendency to foam when latex is mixed with soil can be prevented by the addition of a defoaming agent such as Octanol.

Here again ammoniation of latex fortifies the ability of latex to permeate deeper into the soil without any hindrance of surface coagulation resulting in aggregation of soil particles due to soil acidity, in that ammonia renders the latex sufficiently alkaline but is readily released on standing owing to its high volatility. In this respect ammonia is more advantageous than stable caustic alkalis such as KOH or NaOH for stabilization of latex.

Compression tests: Fig. 1 shows the compression test results for latex mixed specimens of soil.

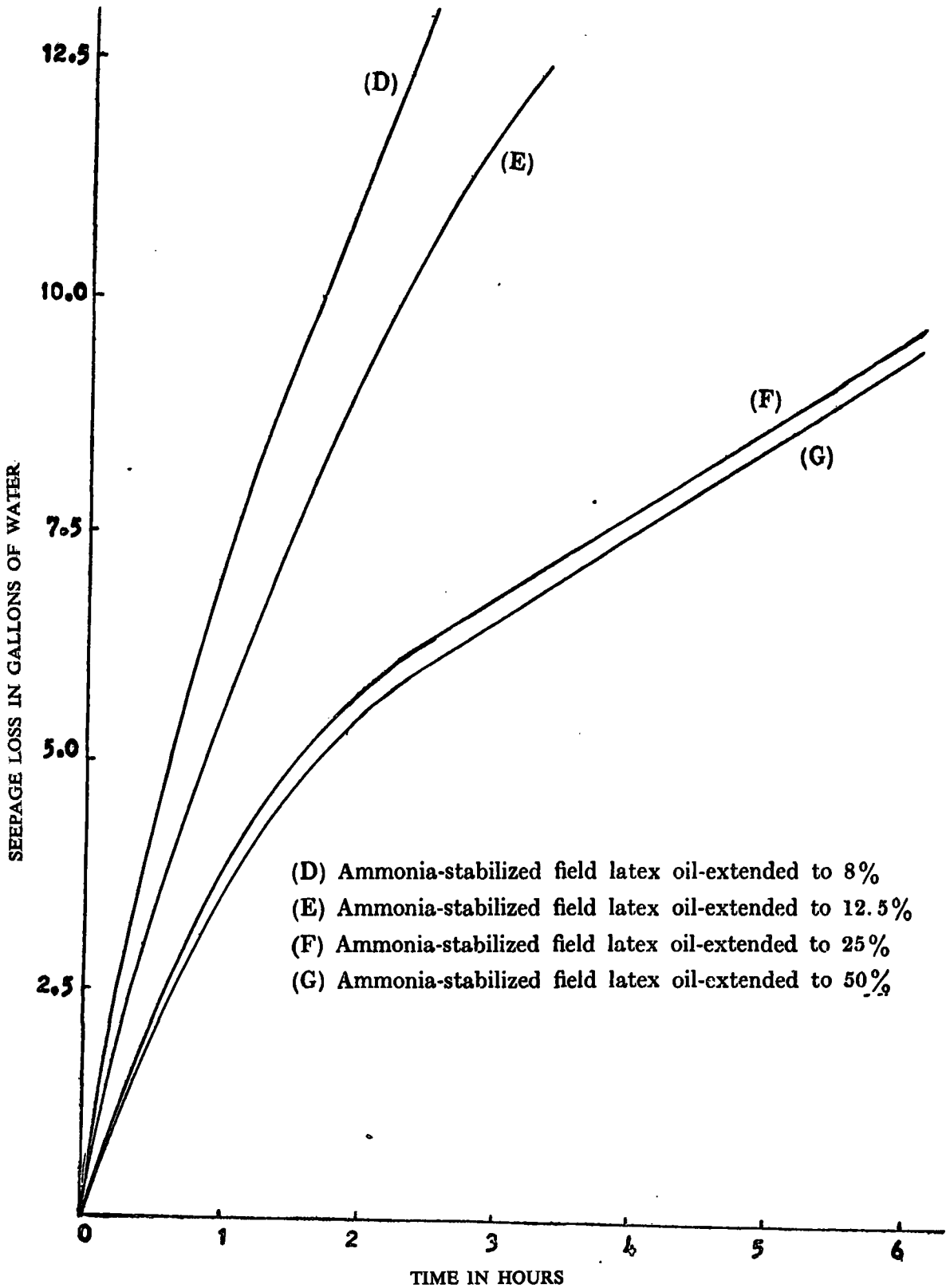


Fig. 3. Effect of oil extension on natural rubber latex for the prevention of seepage losses in soil

The latex modified specimens were distinctly more resistant to compression loads than the plain soil specimens. There is a sharp increase in compression strength when the level of the binder in terms of dry weight in soil is increased from 1 to 3%. The compression strength is only marginally increased above 3%. The results also indicate that field latex, stabilized with 1% ammonia, tends to improve the compression strength of the soil better than field latex stabilized with NaOH or KOH or unstabilized fresh field latex would. Oil extension of field latex with a mineral oil such as Dutrex R, which is an aromatic oil, prior to mixing apparently enhances the binding effect of the soil particles and also improves the seepage resistance of the soil.

Seepage tests: Fig. 2 shows the variation of seepage resistivity of pits treated as described in A and E above compared with that of a control C, which was non-treated, in terms of seepage loss against time taken. This indicates that treatment of the soil with oil-extended high ammonia (HA) latex brings about a marked improvement of seepage resistance over such treatment with HA field latex only, and the latter in turn causes a remarkable decrease of seepage rate over that of untreated soils.

Fig. 3 shows the effect of varying degrees of oil extension of NR latex on the seepage resistance of soils. This indicates that the seepage resistance improves with increasing concentration of oil used and the optimum concentration of oil for this purpose should be about 25% on the dry rubber content by weight and beyond this level the increased improvement on seepage resistivity is only marginal.

DISCUSSION

The exploratory nature of the experimental programme and its limited scope preclude specific recommendations on the general applicability of NR latex to soil stabilization and seepage control.

Many other contributory factors such as long-term stability could distort if not destroy the favourable picture presented. Field evaluation over a number of years will be necessary to determine the service rendered by the various types of lining and other means of seepage control.

Justification for a particular lining may be a complicated procedure. Information on which to base a decision may be insufficient and incomplete and the benefits that may be accrued can seldom be predicted as in the case cited.

Even though the original cost of lining can be reasonably assessed, the cost of maintaining the lining under reasonable conditions is difficult to assess. NR latex offers great potentialities in the treatment of lift irrigation channels in highland cultivation. The Irrigation Department, the Department of Agriculture and other interested bodies should carry out large scale field trials in collaboration with the Rubber Research Institute of Ceylon to confirm these findings.

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REFERENCE

- FUNGAROLI, A. A. AND PRAGER, S. R. (1969). Evaluation of some acrylic polymers as soil stabilizers. *Ind. Eng. Chem. (Production Research & Development)* 8, 450-453.